POWER

Volume 50 New York, Oct. 28, Nov. 4, 1919 *Number 18*

Published December 8, 1919, with current news

The Prescription

OLD DOC COMMON SENSE looked over the rims of his glasses at the lugubrious face of his caller.

"What seems to be the trouble?"

"I don't know," groaned the visitor. "I just ain't able to take any interest in life."

"Appetite good?"

"Fair."

"Pain anywhere?"

"Not a bit."

"Any chills?"

"My feet get cold," admitted the patient.

"Fever, too?"

"Sometimes my head gets hot."

"Um-m-m," mused the Doc. "Hot head and cold feet. Bad symptoms — very bad. Got plenty of pep?"

"That's just the trouble," said the sick man. "Im always tired—never want to keep at a job till it's done."

"Been plugging along pretty steady, have you?"

"Well, not so hard of late. I sort of let up a bit after the war stopped."

"Still put in eight to twelve hours a day, and five to six days a week, eh?" pursued the Doc.

"Well, not quite," answered the patient, beginning to fidget. "Say five or six hours a day and four or five days a week. You see, Doc, I feel so tired——"

"Yes, I know," interrupted the doctor. "And how about your nights? Go to bed early and get plenty of sleep?"

"Well, no; not exactly. You see, my wife she likes theaters, cabarets and motoring, and so on, and I try to please her."

The Doctor slowly brought the tips of his fingers together. Then he cleared his throat ominously.

"I suppose you want me to tell you the truth," he said.

"Sure. I want to know what's ailing me," declared the sick one. But his lips twitched and a frightened look filled his eyes.

"Well, then," the Doc continued, "I'd say you are on the verge of a breakdown. If you keep on at your present pace, I'll not answer for the consequences."

"Ain't there any hope, Doc?"

"Lots of it," reassured the doctor. "You've got a good constitution, but you've got to change your habits. Will you do exactly as I tell you?"

"Sure, Doc!" the patient agreed with alacrity.

"All right, then. I'll give you a prescription, and instead of Latin camouflage and flubdub, I'll put it in plain American, so you can see for yourself that I'm not flimflamming you."

He pulled out his pen, wrote steadily for a minute or two, and handed the writing to the expectant patient. Herewith is the prescription:

COM. N. SENSE, M. D.

Quit killing time—it's a polite form of murder.

Stay on the job eight hours and work every hour of it.

Rest eight hours a day. (You'll have to, if you obey the last paragraph.)

Stop yelling for shorter hours with higher pay. Thirty hours a week won't feed and clothe you.

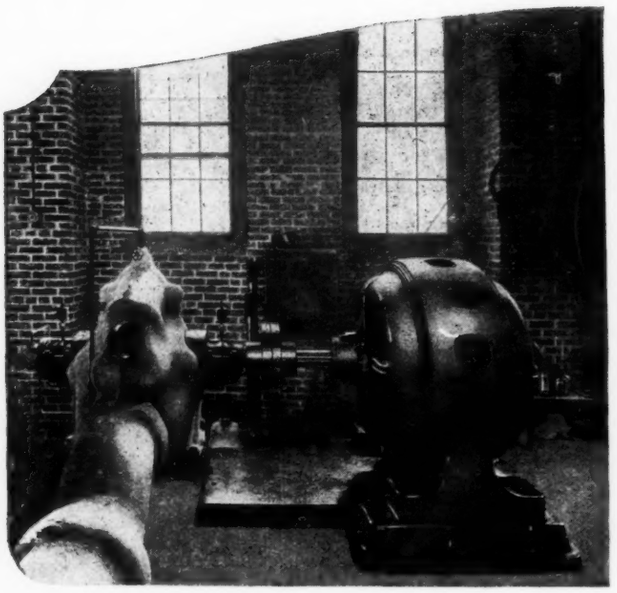
Knock the false doctrines out of your head. Neither laws nor absence of laws can make you happy and contented; but industry, decency and thrift can.

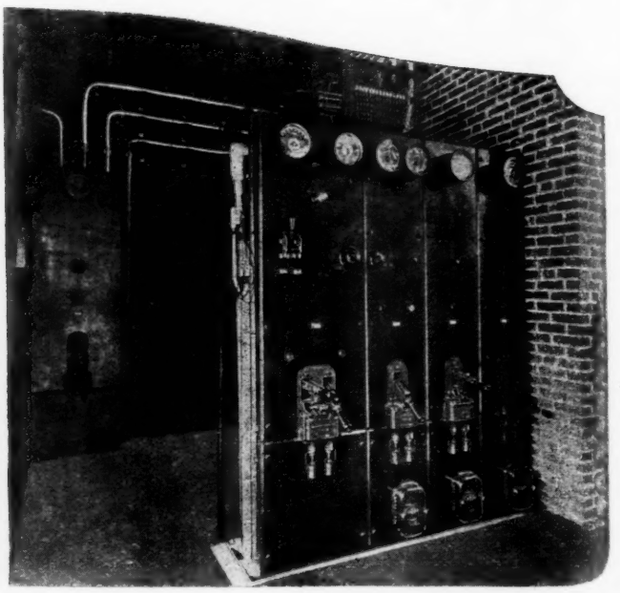
Your ailment isn't physiological—it's psychological. Its name is Laziness and its antidote is Labor.

Quit shamming and malingering.

GO TO WORK!

Contributed by Rufus T. Strohm





The T-Wharf Plant, Quincy Market Cold Storage and Warehouse Co., Boston

By CHARLES H. BROMLEY

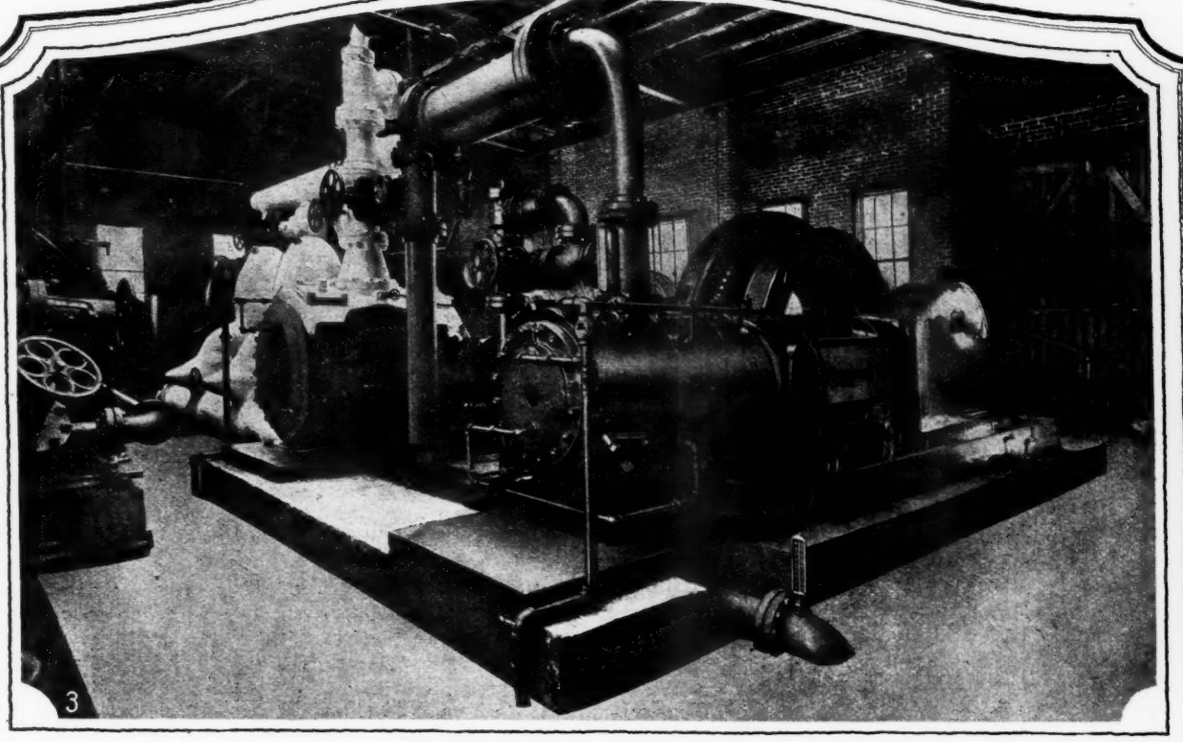
IF Josiah Quincy, who so many years ago froze poultry with salt and ice in that now famous Quincy Market which he gave as a memorial to Boston, could pay the city a visit, he would be both astounded and pleased with the mechanical progress made by the company that bears his name and carries on the work he started. The 1000-ton Quincy Market ammonia compressor excited profound interest and admiration (for complete description see *Power*, Dec. 8 and 15, 1914), but the new electrically-driven, high-speed, feather-valve compressor plant at T Wharf is the most interesting and likely the most valuable piece of refrigerating engineering the country has seen in many a day.

The present building housing the T Wharf station is temporary, the mechanical equipment is permanent. Briefly, the station is of 500 tons rated capacity, in one compound, high-speed, feather-valve ammonia compressor driven by a 600-hp. synchronous motor with energy purchased from the Edison Electric Illuminating Co. There are eight vertical, shell and tube condensers, three horizontal five-pass brine coolers, condensers and coolers being of Quincy Market design. Two induction-motor-driven centrifugal pumps furnish salt water from Boston Harbor for condensing purposes, and one 2200-gal. per min. centrifugal pump, induction-motor-driven, circulates the brine that cools the warehouses. This plant serves seven large warehouses of the Quincy Market Co., the large Clinton Market and several wharf warehouses. See Figs. 1 to 6.

The compressor has a 24-in. stroke, a low-pressure cylinder of 27-in. bore, high-pressure cylinder of 15-in. bore. The low-pressure cylinder has 12 valves, each with a free opening area of 9 sq. in., the high-pressure cylinder 6 valves, each of the same area. At the normal speed of 164r.p.m. the compressor will pump 2665 cu. ft. of gas per minute. The normal suction gas pressure is 5 lb. The compressor in itself is of the standard Laidlaw type, but its gas connections and gas intercooler are of Quincy Market design. The flywheel was selected after studies of statements on flywheel effect with synchronous motors by Westinghouse Electric and Manufacturing Co., General Electric Co. and the Worthington Pump and Machinery Co.—all based on definite crank-effort diagrams, the resultant or final decision being in the nature of a compromise. The slight swing of the ammeter needle indicates excellent all-around balance.

As mentioned, the building is temporary. The piles were cut at the various elevations desired for particular apparatus which they were to support, stringers run across and the apparatus is set upon the stringers.

Now let us go back to the incoming street electrical mains and take up the details of each piece of apparatus in the plant. The station virtually becomes a substation of the Edison Electric Illuminating Co. The current comes to the Quincy Market service switch at 14,000 volts after passing through the Edison company's section of the switchhouse, all fireproof, of course. The transformer is on the Quincy Market line. This is rated at 500 kw., but with ventilation which a 5-hp. fan, soon to be installed, will give, the capacity, even in summer, will be 600 kw. if necessary. All electrical equipment on the Quincy Market side is water- and moisture-proof. That is, a stream of water might be played into the switchhouse, as during a fire, and no short-circuiting would result. The cables are 25,000 volt, and the service switch is an all-inclosed oil switch, remote-controlled. The precipitation of moisture upon the equipment and walls of the switchhouse will not, of course, cause short-circuit. While probabilities of short-circuits due to water and atmospheric moisture may be remote, it is well to provide against them when the load is refrigeration and the demand is for 24-hour daily service, particularly when the volume and value of the stored goods reach the proportions of this warehouse system. Each motor has its own indicating ammeter and integrating wattmeter. These permit of observing



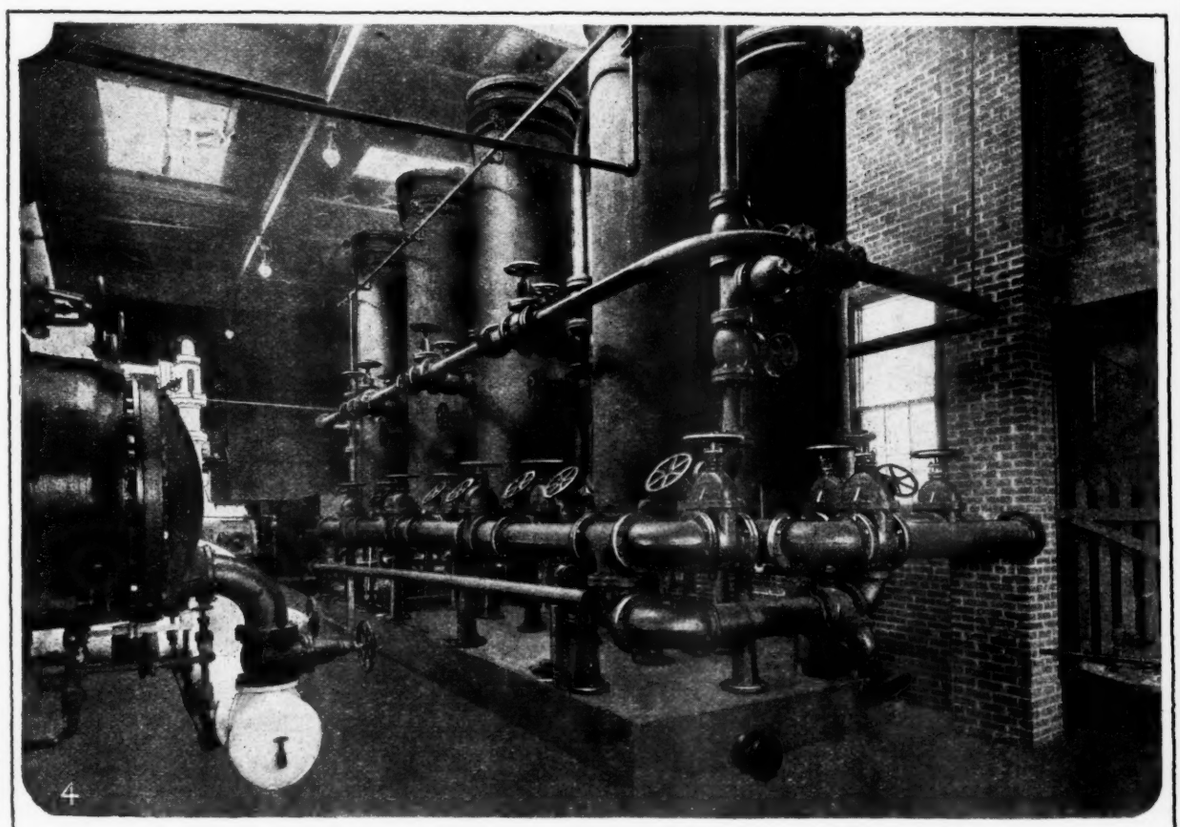


FIG. 3. THE 500-TON HIGH-SPEED, FEATHER-VALVE AMMONIA COMPRESSOR, AND, FIG. 4, THE SHELL AND TABLE CONDENSERS

what effect on current consumption any changes in feeding gas, or brine, or water produces. A Bailey meter will be used on both ammonia suction and discharge to measure gas flow when desired.

A synchronous motor without a heavy flywheel will come up to synchronous speed and lock in without appreciable line surge. The greater the flywheel effect the less this is true; that is, the greater will be the line surge and the more careful the operator must be when he throws on full line voltage, if he would avoid severe line surge. Mr. Fairbanks, chief engineer for the Quincy Market Co., has insured that his operators will do no guessing when making a "shot." Belt-driven from the 15-in. shaft of the compressor (and motor) is a little generator of the kind one sees used so frequently for ignition purposes. When the main motor is at the synchronous speed of 164 r.p.m., a voltmeter-tachometer on the control board and immediately under the line ammeter, magnetized by the little generator, indicates when to throw in full line voltage. This tachometer is not shown in the switchboard view, Fig. 2.

Special Features of Synchronous Motor

The synchronous motor, while not of special design, embodies special features. Any reactive electrical effort coming through the stator of a synchronous motor continues, as lines of force, across the air gap to the rotor when, if the effort is great enough, some member of the rotor—a spoke, the hub, the rim—may fracture. The writer is not here arguing how great such reactive effort might be or how often it may manifest itself; but consideration of this factor led Mr. Fairbanks to modify the design, or rather the materials, of some parts of the standard motor. The rotor, for example, is of cast steel instead of cast iron, giving much greater tensile strength. The bolts holding the coils and those anchoring the motor were increased in size and heat-treated, increasing their elastic limit considerably. Fig. 7 shows plan and elevations of the equipment.

The 15-kw. 125-volt 875-r.p.m. generator for exciting the synchronous motor is belt-driven, as shown in Fig. 5. Exciters for the motors in the permanent plant, when built, will be synchronous and direct-connected.

Now begin with the low-pressure gas in the header immediately above the three horizontal coolers. See Figs. 6 and 8. This header, made of 16-in. pipe, carries a 6-in. dry pipe, both shown in Fig. 8. The dry pipe is welded at each end to a plate that is welded to the header. Notice that the top side—that is, the side opposite the gas-admission side—of the dry pipe has a slit 2 in. wide for its entire length, through which the gas passes into the dry pipe and thence to the suction pipe. To the bottom of the dry pipe is riveted a curved baffle plate which changes the direction of gas flow from the coolers so as to throw out some of the entrained liquid. Both dry pipe and header are given a slight pitch toward the dead end where liquid may drain into the header from the dry pipe and from the header into the coolers. The circular plate in the outlet end of the header has an opening of segment shape into the header, the opening being immediately above that into which the dry pipe is welded and so situated as to pass gas collecting at the top of the header to the suction pipe.

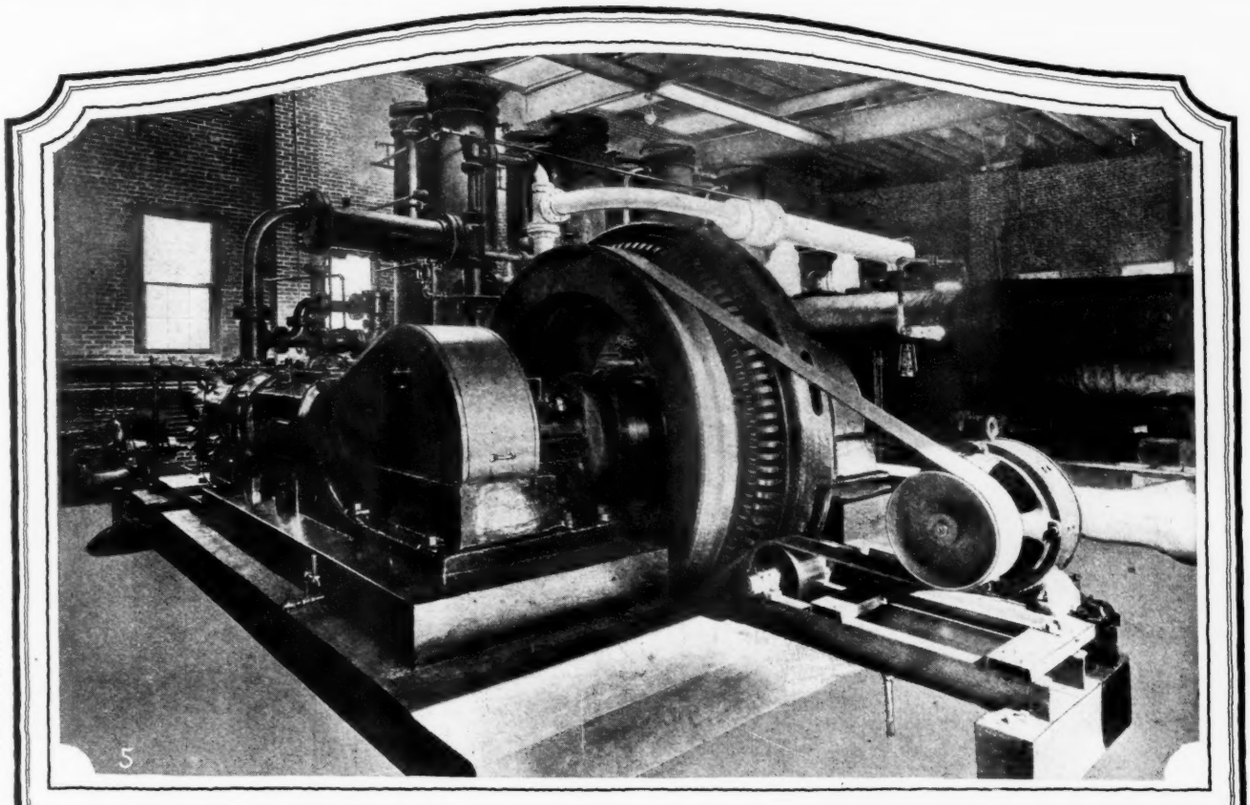
The gas has but about 10 ft. to travel to reach the compressor. This line is horizontal above the compressor, but the drop to the compressor is straight. The suction valves of the compressor are on the top side of the cylinder. The conditions are such that liability to slop over is remote unless the liquid level in the coolers is carried unreasonably high or the feeding of liquid through the expansion (regulating) valves is unnecessarily fast. A slopover here cannot come in one smashing flow; it comes gradually. A large thermometer in the suction line at the low-pressure cylinder immediately indicates that a slopover is trying to take place because the evaporation of liquid from its well sends the mercury down 10 to 15 deg. below the temperature corresponding to the suction pressure. To immediately gasify liquid coming over, the operator has but to open the valve in the bypass between the low-pressure discharge and the suction, admitting hot gas. This, with regulation of the liquid level, is all that is necessary to avoid possible trouble from slopover.

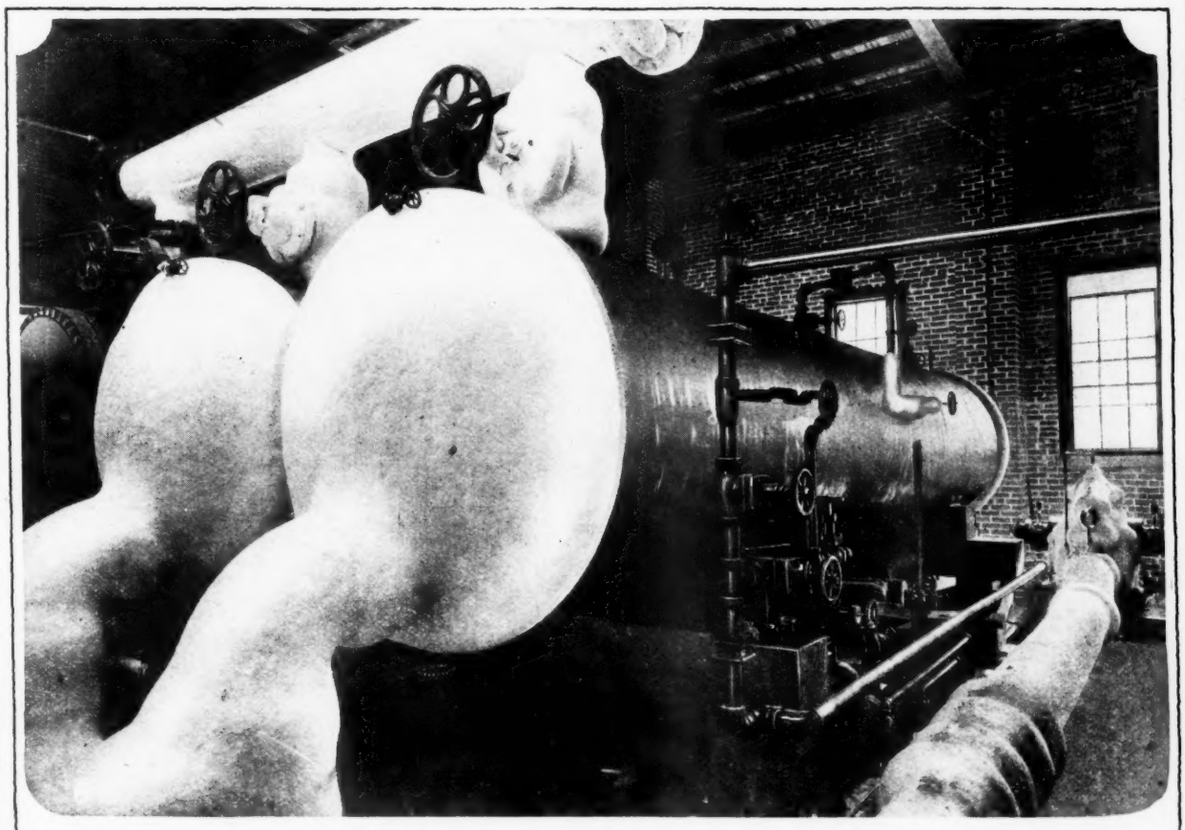
There is a condition, at first surprising, which tends to produce a slopover when the rate of feeding liquid to the brine coolers is suddenly and markedly reduced—not increased, but reduced. The expansion-line nozzle inside the cooler projects the liquid up at an angle on a line with the top far end of the cooler. Feeding may be so rapid that the liquid in the cooler will pile up at this end and thus leave more disengaging volume between liquid level and cooler top at the gas-outlet end than existed before increasing the rate of liquid flow.

A feature of the compressor is the intercooler designed by the purchaser. See Figs. 3 and 8. The cooling medium is liquid ammonia taken direct from the liquid receiver. The principle of the intercooler is identical with that of the open feed-water heater, and the intercooler is provided with trays and baffles just as is the open heater. Liquid direct from the main liquid receiver is run through the intercooler, and what is not evaporated goes to the brine coolers. The gain is, of course, twofold: First, the gas is cooled, reducing the volume to be handled by the high-pressure cylinder; second, liquid in cooling by its own expansion uses up, say, 15 per cent. of its cooling effect in cooling itself. Compared with its condition in the liquid receiver, this liquid passed through the intercooler has already lost this in a more useful way—the liquid as well as the gas has benefited by the heat exchange in the intercooler. As the intercooler pressure is 60 lb. and that in the brine coolers 5 lb., the liquid is trapped just before it reaches the coolers. It is convenient to use the last, or No. 8, condenser as an intercooler, taking the gas before it goes to the liquid-gas intercooler.

A Quincy Market safety valve on the low-pressure cylinder discharge line may blow back into the suction at 125 lb. Another similar make valve set at 200 lb. is placed in the high-pressure cylinder discharge and blows into the high-pressure cylinder suction. A Massachusetts Standard valve, set at 250, discharges to the atmosphere. Later, whatever gas may blow through this valve will be reclaimed.

The ammonia condensers are of the shell-and-tube design and there are eight of them, each of 1073 sq. ft. of tube surface. As seen from Fig. 9 they are vertical, the shells being of 36-in. diameter pipe ⅜ in. thick, welded. The 1½-in. tubes are of piled iron, 12 ft. long, 10 gage, spaced at 2⅛-in. centers, with no lanes between them. Each has one partition giving two passes. Each shell has an expansion ring, electric-welded, and of the same thickness as the shell. The heads are electric-welded. The ammonia-gas connections are 4 in. in diameter and have flanges tool-marked inside the bolt circle, giving the surface sharp V-threads, 24 to the inch. The liquid drains from the bottom of the shells through 1½-in. connections into the liquid headers, of which there are two, one for each four condensers. Equalizing connections are of 1-in. pipe connected in 3 in. below the expansion ring. These connections are tied in with the gas header on the brine coolers so gas may be shut off from any condenser, also





FIGS. 5 AND 6. VIEW OF THE AMMONIA COMPRESSOR FROM THE SYNCHRONOUS MOTOR END, AND, BELOW, SHOWING TWO OF THE THREE BRINE COOLERS IN USE

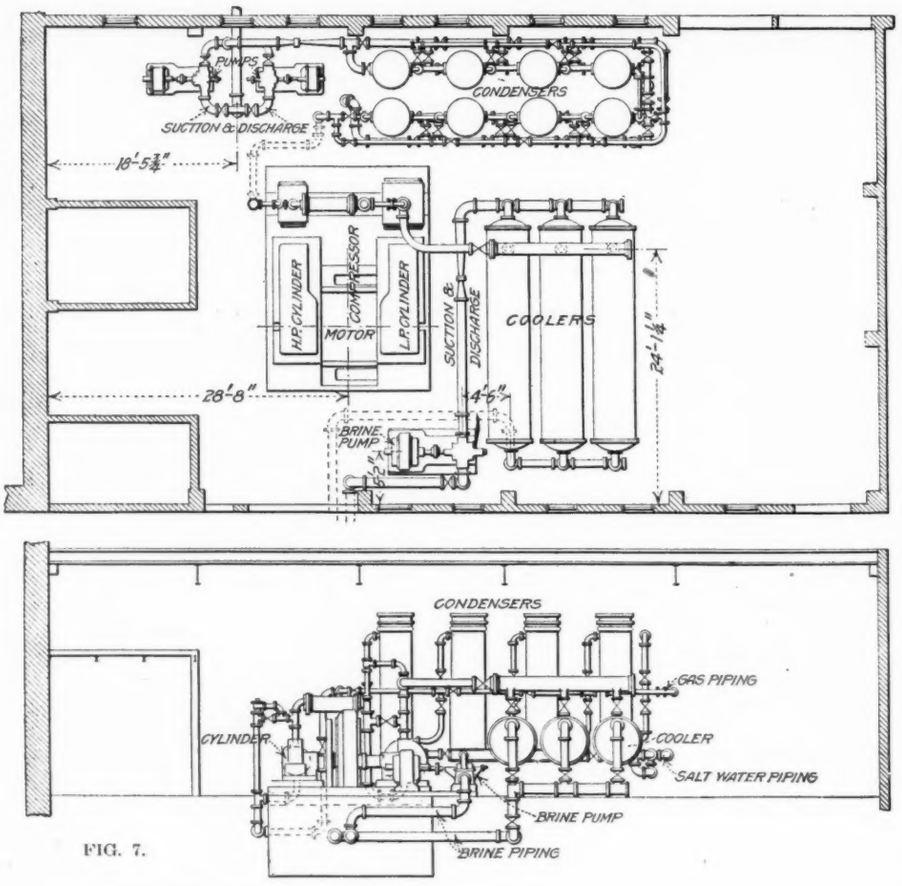
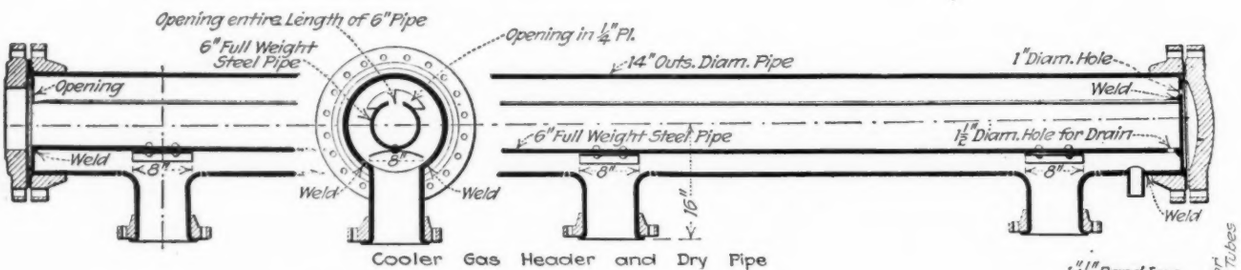


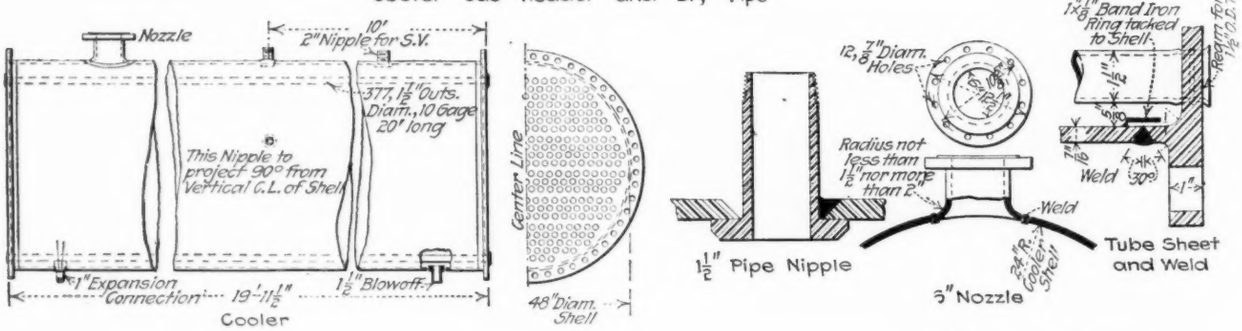
FIG. 7.

FIG. 7. PLAN AND ELEVATION OF EQUIPMENT.

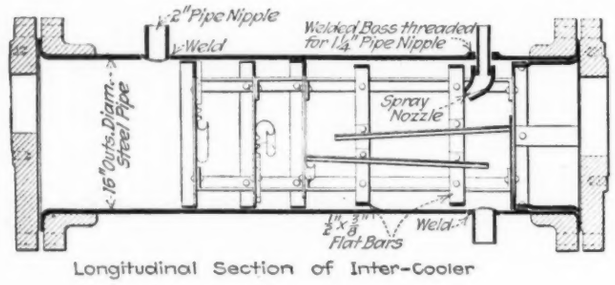
FIG. 8. (TOP) THE GAS HEADER AND DRY PIPE FOR THE BRINE COOLERS. (MIDDLE LEFT) THE BRINE COOLER SHELL AND TUBE SHEET. (MIDDLE RIGHT) DETAILS OF COOLER WELDED CONNECTIONS. (LOWER LEFT) SECTION OF THE LIQUID - GAS INTERCOOLER BETWEEN THE HIGH AND LOW PRESSURE COMPRESSOR CYLINDERS. SPRAY NOZZLE AT LIQUID PIPE INSIDE INTERCOOLER. SECTION OF THE BRINE COOLER HEADS.



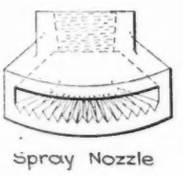
Cooler Gas Header and Dry Pipe



Cooler

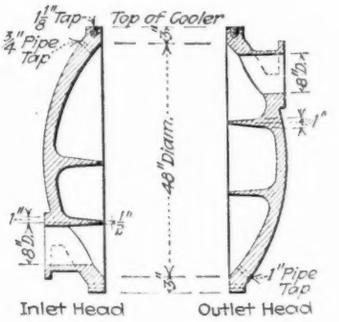


Longitudinal Section of Inter-Cooler



Spray Nozzle

FIG. 8.



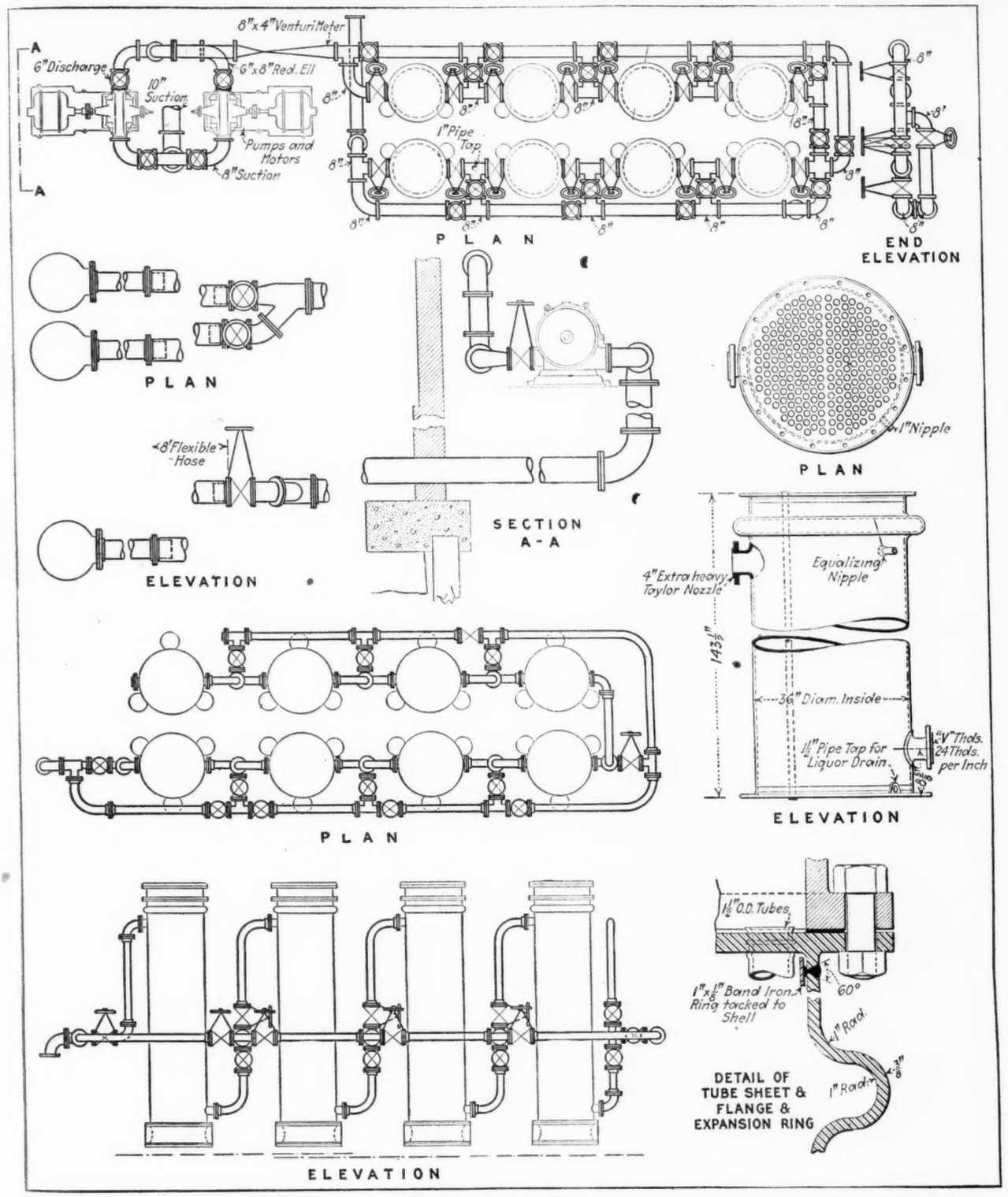


FIG. 9. VARIOUS VIEWS OF CONDENSER CONNECTIONS. THE 8 IN. RUBBER HOSE ON END OF SUCTION PIPE AVOIDS AN EXPENSIVE CRIB.

the water and the liquid evaporated and carried over in to gas header, practically emptying the condenser. It is obvious that should any one or more of the shells "hog" the liquor, it may be conveniently and quickly got rid of by means of the many water and gas connections and valves, which may be manipulated to suit conditions. These condensers may be operated in series or parallel. The ammonia-gas inlet to each shell is 4 in. in diameter, entering the shell at the top through sweeping bends. The gas is directed downward and sweeps at high velocity across the tube bank. Each gas connection is provided with a thermometer well. The cooling velocity will vary between 200 and 300 ft. per minute.

The condensing water is from Boston harbor, circulated by two 6-in. centrifugal volute pumps, each of 1100

gal. per min. capacity, one being sufficient to supply all needed water. The water-ring header around the condensers is 8 in. in diameter. The condensers are counter-current in principle. Each water inlet and outlet to each condenser is provided with a thermometer well; the main outlet and main inlet also have thermometer wells. The circulating water is measured by venturi meter. The practice is to carry about 6 to 8 deg. F. difference in water in and water out of the condensers. During the writer's visit the water in was 55 deg., 63 deg. out. The ammonia liquid was coming out at the same temperature as the water. The chief engineer allows about 2 gallons of cooling water per ton capacity in his condensers, using Boston Harbor water. With condensers free of air, clean and not flooded with liquid, it is expected that there will be realized a pressure in them which is within six to eight pounds of the theoretical.

Substitute for Concrete Crib

The designer has cleverly obviated the use of a concrete crib at the harbor end of the suction pipe. This suction is 10 in. in diameter and at the harbor connects with a 10 × 8 × 8-in. Y. At each 8-in. outlet of the Y is a gate valve, a short nipple on the end of which is fitted with 12 ft. of 8-in. flexible rubber hose. On the end of the hose is a strainer made of 12-in. pipe, slotted to give capacity considerably greater than that of the 10-in. suction. At low tide, or even half tide, each strainer may be hooked to a chain fall, permanently located, lifted, scrubbed and let down again into the water.

The salt-water pumps, besides the usual priming connections, have a priming connection from the top of the pump casing to the top of the valve bonnet on the pump suction.

The horizontal, electric-welded 48-in. diameter 20-ft. long brine coolers, of which there are three, two being in use normally, give remarkable performance. Each has 377 tubes, 1½ in. in diameter, 10 gage, the same as used in the condensers. There are but five passes, the number of tubes in each successive pass being increased and core tubes used to give increased tube surface and increasing velocity to the brine as the temperature head decreases. For example, the first pass has 62 tubes, the last pass 110 tubes with core tubes. The brine comes in at the bottom and out at the top, circulated by an 8-in. centrifugal pump, induction-motor-driven at 1170 r.p.m. Calcium brine of 1.227 to 1.230 sp. gr. is used, 1500 to 2200 gal. being circulated per minute. The temperature difference in and out is usually held at 5 deg. F.; that is, from — 5 deg. in to — 10 deg. out. The velocity through the cooler is about 400 ft. per min. The writer observed the coolers for several days, and at no time excepting once during a slight slop-over was there a perceptible difference between the temperature of the gas at the gas header to the coolers and the brine out; both were —10 deg. all the time, with but two coolers in and the capacity up to full rating. The brine flow is measured by a 10 x 5-in. venturi meter in the pump discharge, between the pump and coolers. In designing allowance was made for a brine flow of 5 gal. per min. with 5 deg. temperature range per ton of 24 hours.

The liquid enters the cooler through a nozzle in the bottom of the shell, projecting it up at an angle about in line with the upper far end of the shell. Each shell has a 2-in. nozzle, welded, for a safety valve. The tubes are fastened in the heads, as shown in Fig. 8. Attention is called to the design of the tube sheet and where it joins the 7/16-in. thick steel shell.

The liquid-level telltale is plainly shown in Fig. 6. Soon feeding of the liquid will be automatic for these coolers. Thermometer wells are liberally provided in the liquid, gas and brine connections.

Practically all ammonia piping is of light weight, no extra-heavy pipe being used. Joints are all flanged, except for small piping when screwed connections are made.

Regulation of capacity to suit the load is had by varying the flow of brine and by shutting down the plant altogether for a period of hours. The latter method is, everything considered, most desirable. One man on a watch easily handles the operation of the plant.

This article would be incomplete without describing one of the provisions in electrically welding the coolers and condensers stipulated by the designer. See Fig. 8. Inside the vessel to be welded and over and ⅛ in. away from the beveled edges of the two parts to be joined, a 1 x ⅛-in. iron band ring is tacked. The gas and slag which ordinarily would get caught at the bottom of the joint are thus free to blow through and allow the bond to become solid. The welds were examined and tested by cutting out samples from three equidistant points around the welded seam. In case of suspicion one or two more might be cut out.

The samples are subjected to physical test and microphotographed. No seams were condemned. After the holes from which the samples were taken were filled by welding, the shells were subjected to working pressure of air (300 lb. for the condensers, 150 lb. for coolers) and the welds painted with soap-and-borax suds. This test completed, the air was let out and a hydrostatic test at 1½ times the working pressure, in accordance with the Massachusetts Rules, was given. The pressure was then dropped to working pressure and the welds were subjected to sharp blows of a 10-lb. hammer.

Steam for heating the plant is taken from the Richmond Street plant a few blocks away; the line carried across Atlantic Ave., thence to T Wharf under water in the harbor. The pressure is 90 lb. at T Wharf. The condensate which forms is collected in the tank on the wall and used for washing or other service to which hot water may be put. One large heating coil is placed under the floor where the operator stands much of the time.

The plant and most of its equipment was designed by Frank L. Fairbanks, chief of the mechanical department of the Quincy Market Cold Storage & Warehouse Co.

The Million-Dollar Brand

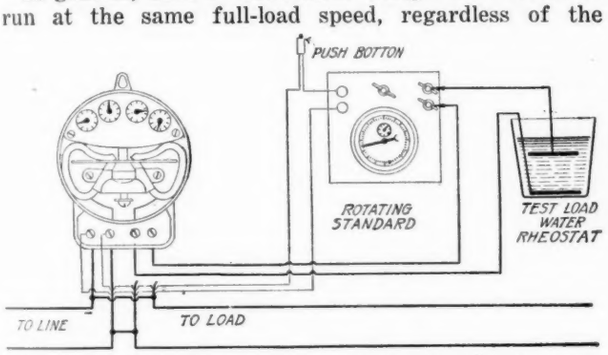
Word comes from Milwaukee of another coal saver known as the Million-Dollar Brand. It is in line with other nostrums of a similar character, but the claims of the inventor, W. Gottschalk, are so amusing from an engineering standpoint that they will bear repetition. In an advertisement appearing in one of the daily papers one gallon of this wonderful material mixed with two gallons of hot water will make "two tons of coal capacity 50 per cent. more heat and reduce the ashes to one-fourth." In other words, it will save 50 per cent. of the coal by making one ton the equivalent of two, thus reducing the cost of coal from $13 per ton to $6.50. With each can of this 50 per cent. coal saver are included "directions for using and sworn testimonials, affidavits and references of well-known citizens and firms of Milwaukee and Chicago, including recommendations of high society women." Fortunately, engineers were omitted from the inventor's collection of references.

Testing Single-Phase Watt-Hour Meter With a Rotating Standard of Different Make

By P. B. FINDLEY

IN AN article, "Testing Single-Phase Watt-Hour Meters With a Rotating Standard," which appeared in *Power*, Feb. 4, 1919, the author described the method of testing a single-phase watt-hour meter in comparison with a standard watt-hour meter or "rotating standard." Such standard instruments are a part of the regular "line" put out by their makers and have in general the same constants as the commercial instruments. That is, at full rated load they run the same speed as do similarly rated commercial instruments. When two such instruments are connected to the same load, it is obvious that if the test meter is 100 per cent. accurate it will make just the same number of revolutions as the standard in any given period. The formula for the per cent. error, if any, is the simple one, $E = \left(\frac{N}{M} - 1\right) 100$, where E equals the error in per cent., N the revolutions of the service meter and M the revolutions of standard meter.

In general, each manufacturer designs its meters to run at the same full-load speed, regardless of the



CONNECTIONS FOR TESTING SINGLE-PHASE METER WITH ROTATING STANDARD

rating. This uniform full-load speed is different for the different makes and types of meters, hence a tester who must make one rotating standard meter serve for all sorts of service meters is sure to find one or more meters for which the foregoing simple formula will not hold. Suppose the standard meter is a Westinghouse instrument and it is necessary to test a General Electric type I, 5-ampere, 100-volt meter. Using the proper range of the standard, that is, 5 amperes, 100 volts, and loading it to 500 watts, it will run at 25 r.p.m. However, when the service instrument is metering 500 watts, it will run at 27.78 r.p.m., if it is 100 per cent. accurate. In other words, when the two meters are connected to the same load, as in the figure, we must adjust the service meter so that it makes exactly 27.78 revolutions while the standard is making 25. The speed at which the service meter operates can be obtained from the formula, $S = \frac{WT}{K \times 3600}$ where S is the revolutions per minute of the service meter; W the full-load watts, in this case 500; T the time in seconds, 60; and K a constant, for the meter in question $K = 0.3$. Then $S = \frac{500 \times 60}{0.3 \times 3600} = 27.78$ revolutions per minute. Since, however, a fractional number of revolutions of a service-meter disk cannot be read accurately, an integral number is chosen, such as 30, and find the proportionally greater number of revolutions of the standard, which may be obtained from the formula, $N_R = \frac{S_R N_S}{S_S}$, where N_R is the number of revolutions of the standard meter corresponding to the chosen integral number of revolutions, N_S, for the service meter; in this case N_S is made 30; S_R the full-load speed per minute of the rotating standard, being 25 for the meter in question; and S_S the full-load speed per minute of the service meter, in this problem 27.78. Then $N_R = \frac{25 \times 30}{27.78} = 27$ revolutions. In actual testing the number of revolutions N_R of the standard is found, while the service meter disk revolves 30 times and if this (N_S) is 27, the accuracy is 100 per cent.

In order to facilitate testing, makers of standard meters furnish tables which give, for each make of service meter usually met, the number of revolutions of the standard meter for various percentages of accuracy. Such a table for three different makes of service meters is reproduced herewith. Counting from the left, columns 1 and 2 give the make and rating of the service meter, columns 3 and 4 give the number of revolutions to be observed at full and light loads respectively. Column 5 gives the current range of the standard meter to be used. The next group of columns gives the number of revolutions of the standard which will occur while the service meter is making the number of revolutions given in column 3 or 4, assuming various percentages of accuracy.

Returning to our example of the G. E. type I, 5-ampere, 100-volt meter, use the line across the table indicated by the dagger. As shown above, if 30 revolutions of the service meter are observed, we would find that with 100 per cent. accuracy the standard meter made 27 revolutions in the same time. If, however, the standard made but 26.21 revolutions, the accuracy, or, better named, the per cent. registration, would be 103 per cent.; that is, the service meter would be 3 per cent. fast. If the figure were 26.08, the service meter would be about 3.5 per cent. fast, and so on. It is thus a simple matter to glance at the table and determine roughly the error that has to be adjusted for after each observation.

The tester who wants to master the profession is going to ask next, "How is that table constructed?" The best way to answer this is to start with the assumption that we have no table at all, an actual condition sometimes met. First of all, the fundamental constant of a watt-hour meter *is the watt-hours measured for one revolution of the disk*, and is represented by K. This constant depends of course on the construction and adjustment of the metering element, and the various gears of the register are designed from it to translate revolutions of the shaft into watt-hours upon the dials. In the last group of columns at the right of the table are given the values of K, the

values in columns headed "Service" being for the meters listed in columns 1 and 2. The constant for any particular meter can be found marked somewhere on it—on the inside of the terminal box cover, on the disk or on the dial-plate.

To compare two meters we use the formula:

$$\textit{Per cent. registration} = \frac{N_S\ K_S}{N_R\ K_R} \times 100$$

where N_S = observed revolutions of service meter;
N_R = observed revolutions of standard meter;
K_S = watt-hour constant of service meter;
K_R = watt-hour constant of standard meter.

If two similar meters are being compared, we have $K_S = K_R$ and the per cent. registration is $\frac{N_S}{N_R} \times 100$, which is the same as the formula mentioned at the beginning of this article.

Returning again to the case of the G. E. type I meter, we find that its constant is 0.300; and that of the Westinghouse standard is 0.333. Substituting these values in the formula, and assuming that we have found that 27 revolutions of the standard (N_R) correspond to 30 of the service meter (N_S) we have:

$$\textit{Per cent. registration} = \frac{30 \times 0.300}{27 \times 0.333} \times 100 = 100\ \textit{per cent.}$$

therefore, the service meter is in perfect adjustment. If, however, we had read 28 revolutions of the standard, then the percentage registration would be

$$\frac{30 \times 0.300}{28 \times 0.333} \times 100 = 96.4 \text{ or } 3.6 \text{ per cent. slow.}$$

It is now a simple matter to construct the table. Letting P equal per cent. registration, and solving for N_R we have $N_R = \frac{N_S K_S}{P K_R} \times 100$. Using the values of the illustration $N_R = \frac{30 \times 0.300}{P \times 0.333} \times 100$. Then substituting various values of P from 94 to 106, we will get the figures in the table for that particular case and by using proper values for N_S, K_S and K_R, we can construct the entire table.

In the practical use of the table it is worth remembering that the figures for the values of N_R increase above the rotating standard's 100 per cent. value, if the service meter is "slow," and decrease if the service meter is "fast," and that the change is about 1 per cent. of the "standard" value for each 1 per cent. change in registration of the service meter. If the accuracy of the service meter, after adjustment, must be within, say, 2 per cent. fast or slow, the simplest way is to make up a table giving only the service-meter ratings, the number of revolutions to be observed and the revolutions of the standard meter given in the "98 per cent." and "102 per cent." columns. The service meter is then adjusted till the reading of the standard falls within these limits. It is better as a rule to record at each test the actual accuracy of the service meter, in which case the complete table is necessary.

Tables similar to that used in this article are furnished on request by the manufacturers of standard watt-hour meters.

DATA FOR TESTING 60-CYCLE SINGLE-PHASE WATT-HOUR METERS WITH SINGLE-PHASE PORTABLE STANDARD

Make	Service Meter: Ampere Capacity	Service Meter: Revolutions Heavy Load	Service Meter: Revolutions Light Load	Portable Standard Meter: Ampere Capacity	Revolutions of Standard for 94 per Cent.	95 per Cent.	96 per Cent.	97 per Cent.	98 per Cent.	99 per Cent.	100 per Cent.	101 per Cent.	102 per Cent.	103 per Cent.	104 per Cent.	105 per Cent.	106 per Cent.	Watt-Hours per Rev. 100-110 Volt Meters: Service	100-110 Volt Meters: Standard	200-220 Volt Meters: Service	200-220 Volt Meters: Standard
Westinghouse Types B and C	5	25	...	5														0.333	0.333	0.666	0.666
	10	25	...	10	26.60	26.32	26.04	25.77	25.51	25.25	25.00	24.75	24.51	24.27	24.04	23.81	23.58	0.666	0.666	1.333	1.333
	20	25	...	20														1.333	1.333	2.666	2.666
	40	25	..	40														2.666	2.666	5.333	5.333
	5	..	1.0	5														0.333	0.333	0.666	0.666
	10	..	1.0	10	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.666	0.666	1.333	1.333
	20	..	1.0	20														1.333	1.333	2.666	2.666
	40	..	1.0	40														2.666	2.666	5.333	5.333
	15	20	..	10														1.00	0.666	2.00	1.333
	30	20	...	20	31.91	31.58	31.25	30.93	30.61	30.30	30.00	29.70	29.41	29.13	28.85	28.57	28.30	2.00	1.333	4.00	2.666
	60	20	...	40														4.00	2.666	8.00	5.333
	15	..	1	10														1.00	0.666	2.00	1.333
	30	..	1	20	1.60	1.58	1.56	1.55	1.53	1.52	1.50	1.49	1.47	1.46	1.44	1.43	1.42	2.00	1.333	4.00	2.666
	60	..	1	40														4.00	2.666	8.00	5.333
	80	15	...	40	31.91	31.58	31.25	30.93	30.61	30.30	30.00	29.70	29.41	29.13	28.85	28.57	28.30	5.333	2.666	10.666	5.333
	80	..	1	40	2.13	2.11	2.08	2.06	2.04	2.02	2.00	1.98	1.96	1.94	1.92	1.90	1.89				
General Electric Type I	3	30	..	5	19.15	18.95	18.75	18.56	18.37	18.18	18.00	17.82	17.65	17.48	17.31	17.14	16.98	0.200	0.333	0.400	0.666
	3	..	2	5	1.28	1.26	1.25	1.24	1.22	1.21	1.20	1.19	1.18	1.17	1.15	1.14	1.13				
	5†	30	..	5	28.72	28.42	28.12	27.83	27.55	27.27	27.00	26.73	26.47	26.21	25.96	25.71	25.47	0.300	0.333	0.600	0.666
	10	30	...	10														0.600	0.666	.....	.....
	5	..	2	5	1.91	1.89	1.88	1.86	1.84	1.82	1.80	1.78	1.76	1.75	1.73	1.71	1.70	0.300	0.333	0.600	0.666
	10	..	2	10														0.600	0.666	.....	.....
	200 10*	32	...	10	31.91	31.58	31.25	30.93	30.61	30.30	30.00	27.70	29.41	29.13	28.85	28.57	28.30	.....	.....	1.25	1.333
	200 10	..	2	10	1.99	1.97	1.95	1.93	1.91	1.89	1.88	1.86	1.84	1.82	1.80	1.78	1.77	.....	.....		
	15	30	...	20	23.94	23.69	23.44	23.20	22.96	22.73	22.50	22.28	22.06	21.84	21.63	21.43	21.23	1.00	1.333	2.00	2.666
	15	..	2	20	1.60	1.58	1.56	1.55	1.53	1.52	1.50	1.49	1.47	1.46	1.44	1.43	1.42				
	25	30	...	20	35.90	35.53	35.15	34.79	34.44	34.09	33.75	33.42	33.09	32.77	32.45	32.14	31.84	1.50	1.333	3.00	2.666
	50	30	...	40														3.00	2.666	6.00	5.333
	25	..	2	20	2.39	2.37	2.34	2.32	2.30	2.27	2.25	2.23	2.21	2.18	2.16	2.14	2.12	1.50	1.333	3.00	2.666
	50	..	2	40														3.00	2.666	6.00	5.333
Fort Wayne Type K	5	30	...	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.25	0.333	0.50	0.666
	10	30	...	10														0.50	0.666	1.00	1.333
	..	..	...	..	23.94	23.68	23.44	23.20	22.90	22.73	22.50	22.28	22.06	21.84	21.63	21.43	21.23	.....	.....	.....	.....
	5	..	2	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.25	0.333	0.50	0.666
	10	..	2	10														0.50	0.666	1.00	1.333
	..	..	...	..	1.60	1.58	1.56	1.55	1.53	1.52	1.50	1.49	1.47	1.46	1.44	1.43	1.42	.....	.....	.....	.....

Load service meter to give revolutions stated in table in about one minute's time.
* Speeds for 200-220-volt meters are same as for 100-110-volt when the 200-volt coil of standard is used, except in the case of 10-ampere type I meters.
† Example referred to in text.
Westinghouse Type A and Round Type meters make 50 revolutions per minute at full load; therefore, the revolutions of service meter should be taken as double that given in table for types B and C.

Repairing Drumshaft Bearing on Elevator Machine

By D. Alfred Manson

On a large freight elevator so arranged that the cable drum may be driven from the wormshaft or by the back gears, which reduces the speed in the ratio of about one to four and increases the load-carrying capacity to the limit of safety of the cables, trouble was experienced with the drumshaft bearings. By referring to Fig. 1 it will be seen that the bolts of the mainshaft coupling at *B* are used for direct drive, while those of the pinion *A* are removed and the pinion is secured out of mesh by a collar. For slow speed the pinion is bolted to the flange on the back-gear shaft and coupling bolts *B* are removed. In this last arrangement the drum is free to turn upon its shaft, turning in the same direction but at a slower speed than its supporting shaft.

This slow motion is intended for occasional use only, but on account of the expected arrival from day to day of some heavy machinery at our plant, it was allowed to remain in slow gear for over a week. The bearings supporting the drum upon its shaft were provided with compression grease cups and they were well filled with grease. The cups did not work, however, probably due to too hard grease or an accumulation of dirt in the passages. As a result the bearing of the drum, which was of cast iron, became badly worn. The shaft is 6 in. in diameter and the drum's bearing

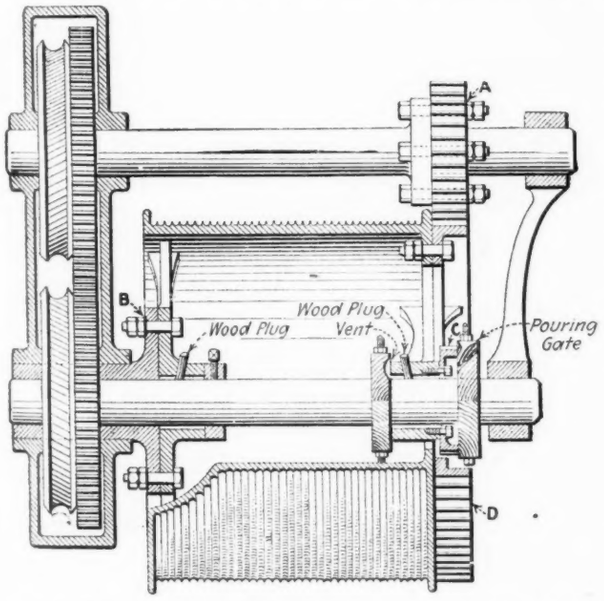


FIG. 1. SECTION THROUGH ELEVATOR DRUM AND CRANES

cut itself to about 7 in. diameter before attention was drawn to it by the peculiar rumbling sound.

This is a very busy machine and is kept in use for twenty-four hours daily, so it was decided to make a temporary repair until such time as the rush was over, when the shaft could be renewed as well as bronze bushings fitted into the drum. The emergency repair was made as follows:

First, all strain of the cables had to be removed from the drum. This was done by suspending the car with heavy ropes from the overhead framework, while the counterweight was raised by jackscrew placed in the pit. The gearing was put back to high speed, which centered that end of the drum about the shaft with its own coupling bolts, as at *B*. The other end was now in the air with no assurance that it was concentric with the shaft. It was assumed that the bearing had cut itself large by an equal amount all the way around. This was measured and it averaged about one-half inch radially.

Four pieces of cast iron ½-in. square and of the length of the drum bearing were cut halfway through at three points, as in Fig. 2, and then pushed in equidistant around the opening between shaft and bearing. A piece

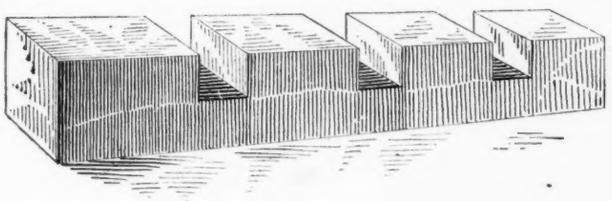


FIG. 2. SHAPE OF CAST-IRON PIECES PLACED IN DRUM-SHAFT BEARINGS

of hard wrapping paper was put around the shaft before the iron spacers were put in. This served the purpose of keeping the babbitt from adhering to the irregularities on the shaft and gave clearance for grease.

There is a gear *C* bolted to the end of the drum bearing, its purpose being to operate the limits. The bore of this gear was cut large by the same amount as the drum bearing, and the bolts were bent and otherwise damaged. This gear was centered true with the shaft and secured by new bolts. Two wooden collars, made in two sections, were now fitted around the shaft, one at the inside end of the bearing, the other at the outside of the limit gear. A wooden plug was pushed into the oil hole, now drilled clear, until it came in contact with the paper around the shaft. After providing a vent and a pouring gate in the wood collars, the collars were luted with asbestos mixed with oil instead of water, to prevent a blow. The babbitt was poured a little hotter than usual practice, and this proved a success. The other bearing was much easier, as there was no gear and it was already centered and held by the coupling bolts.

The paper that had been placed about the shaft was left inside the babbitt, but caused no trouble before it was broken up and forced out in operation. It was hoped this repair would last for at least three months. As a matter of fact, it was two years and six months before the babbitt began to crack and necessitate the permanent repairs. The job was completed in nine hours by a mechanic and two helpers.

Where an electric power company was sued for loss of a telephone exchange by fire, alleged to have been started through negligence of the power company in permitting a current of electricity on its wire to come in contact with plaintiff's telephone wire and be transmitted into the building and switchboard, plaintiff was entitled to recover on a theory either that a negligent overcharge of defendant's wire or failure to use proper means or appliances to avoid contact between the wires was the cause of the fire. (Alabama Supreme Court, Davidson vs. Alabama Power Co., 82 Southern Reporter, 91.)

The Salaries of Operating Engineers

FROM a number of letters received by *Power* there seems to be a feeling among engineers that their wages are not up to the level of those of other occupations requiring the same amount of skill and responsibility. In order to arrive at the truth of the matter, *Power* sent a questionnaire to a number of operating engineers throughout the country, asking for information as to hours, wages and type and size of plant. The replies to these letters have been classified and the information is now presented, together with data gathered from other sources.

Tables I to V give the information from the questionnaires, classified by type of plant, as follows: (1) Central stations; (2) railway plants; (3) hotels, apartments and public buildings; (4) office buildings; (5) industrial plants. Each table has been arranged geographically, beginning with the northeastern part of the country and working westward and southward to California. Capacities of plants were given, some in kilowatts and some in horsepower. For uniformity, these are all given in the tables on a basis of kilowatts, although some of the plants do not generate electric power. The hours given are hours' work per day. Although wages are paid on every basis from hourly to yearly, the table shows the equivalent monthly rate for all cases.

Table VI gives a summary of salary data for chief engineers and watch engineers, collected from New York City, independently of the questionnaire referred to. Table VII gives similar data from New Jersey near New York City, Table VIII from Chicago, and Table IX from St. Paul, Minn. In a number of cases the original data at hand showed wages per hour, but omitted the hours per day or days per week. In these cases the monthly rate was not computed, but the rate per hour is given.

The city hall plant in a large Eastern city employs one chief engineer at $2,000 per year, three assistant engineers at $4.75 per day, three operating engineers at $4.25, five pumpmen and three dynamo men at $3.50, and twenty firemen at $4 per day. All engineers and pumpmen carry engineers' licenses, and all employees work eight hours per day. In the same city, in an industrial plant, the following amounts are paid: Chief engineer, $195; watch engineer, $173; firemen, $138.50 per month. In this case watch engineers work twelve hours and firemen eight hours per day. Another indus-

TABLE I. SALARIES IN CENTRAL STATIONS*

Locality	Capacity in Kw. Basis	Source of Power	Method of Firing	Ch. Engr. Hr.	Ch. Engr. Sal.	Watch Engrs. Hr.	Watch Engrs. Sal.	Oilers Hr.	Oilers Sal.	Firemen Hr.	Firemen Sal.	Ch. Electricians Hr.	Ch. Electricians Sal.	Electricians Hr.	Electricians Sal.	Switchboard Operators Hr.	Switchboard Operators Sal.	Pipe Fitters Hr.	Pipe Fitters Sal.	Laborers Hr.	Laborers Sal.
Maine	24,000	Water	.....	..	208	8	108	8	104	..	...	8	114	8	104	8	127	8	104	8	89
Vermont	7,500	Steam	.....	..	140	9	112	..	...	9	104	9	120	9	100	9	96	..	...	9	88
New York state	2,000	Water and Purchased Steam	Hand	8	150	8	120	..	...	8	115	..	150	8	85	..	...	..	...	..	...
New York state	670	Steam	Hand	8	152	8	105	8	104	..	...	..	...	..	...	..	...	..	...	..	...
Washington, D. C.	1,000	Steam	Hand	12	150	12	105	..	...	12	98	..	...	..	...	..	...	..	...	..	...
Virginia	5,250	Steam	Stoker	8	175	8	155	..	...	8	105	..	...	9	170	..	...	..	...	9	136
West Virginia	15,000	Steam	Stoker	..	275	8	173	8	154	8	142	..	...	..	...	8	132	9	228	9	120
Ohio	35,000	Steam	Stoker	8	250	8	175	8	156	8	156	8	225	8	154	8	135	8	134	8	104
Ohio	1,200	Steam	Hand	..	175	..	145	..	...	..	130	..	...	..	...	..	...	..	...	..	...
Ohio	9,250	Steam	Stoker	12	200	12	200	12	164	12	173	..	...	..	...	..	...	..	...	..	...
Missouri	425	Steam	Hand	8	160	8	122	..	...	8	108	..	...	..	...	..	...	..	...	..	...
Colorado	30,000	Steam	Stoker	..	185	8	135	..	...	8	130	8	145	8	118	8	112	8	140	..	...
Oklahoma	6,000	Steam and Gas	Oil and Gas	..	300	12	180	12	150	12	180	8	175	8	145	..	...	10	165	10	110
New Mexico	1,725	Steam	Hand	12	175	8	115	..	...	8	105	..	...	..	...	..	...	8	90	..	...
San Diego, Cal.	11,250	Steam	Oil	8	225	8	140	8	115	8	120	..	...	8	180	8	120	8	120	8	93

*Salaries on basis of dollars per month.

TABLE II. SALARIES IN RAILWAY PLANTS

Locality	Capacity in Kw. Basis	Source of Power	Method of Firing	Ch. Engr. Hr.	Ch. Engr. Sal.	Watch Engrs. Hr.	Watch Engrs. Sal.	Oilers Hr.	Oilers Sal.	Firemen Hr.	Firemen Sal.	Ch. Electricians Hr.	Ch. Electricians Sal.	Electricians Hr.	Electricians Sal.	Switchboard Operators Hr.	Switchboard Operators Sal.	Pipe Fitters Hr.	Pipe Fitters Sal.	Laborers Hr.	Laborers Sal.
Vic. of N.Y. City	175,000	Steam	Stoker	8	300	8	250	8	142	8	155	8	300	..	...	..	...	8	160	8	132
New York state	1,790	Steam	Stoker	8	240	12	190	8	114	8	116	..	...	..	...	..	...	..	...	8	116
New York state	2,000	Steam	Hand	8	150	8	120	..	...	8	115	..	150	8	85	..	...	..	...	..	...
Alabama	1,350	Steam	Hand and Stoker	10	242	8	160	8	90	8	95	..	220	..	...	..	...	..	...	8	105
Middle West city	12,000	Steam and Purchased	Stoker	12	250	12	190	8	104	8	104	..	...	..	...	8	116	8	125	8	90
Not stated	1,350	Steam	Hand	..	230	8	163	8	90	8	90	..	...	..	...	..	...	..	...	..	...

TABLE III. SALARIES IN HOTELS, APARTMENTS AND PUBLIC BUILDINGS

Locality	Capacity in Kw. Basis	Source of Power	Method of Firing	Ch. Engr. Hr.	Ch. Engr. Sal.	Watch Engrs. Hr.	Watch Engrs. Sal.	Oilers Hr.	Oilers Sal.	Firemen Hr.	Firemen Sal.	Ch. Electrician Hr.	Ch. Electrician Sal.	Electricians Hr.	Electricians Sal.	Pipe Fitters Hr.	Pipe Fitters Sal.	Laborers Hr.	Laborers Sal.
Central Massachusetts	400	Steam	Hand	8	180	8	120	..	...	8	104	..	...	8	140	..	...	..	...
New York state	746	Steam	Stoker	8	145	8	93	..	...	8	85	..	...	..	...	..	...	..	...
New York state	112	Steam and Purchased	Hand	..	...	8	125	..	...	‡8	100	..	...	..	...	..	...	..	...
Washington, D. C.	525	Steam	Stoker	8	170	8	120	8	90	8	95	8	135	8	120	8	110	8	80
Washington, D. C.	350	Steam	Stoker	8	208	8	150	..	...	8	100	..	...	..	...	..	...	..	...
Washington, D. C.	150	Steam	Hand	12	145	12	110	..	...	12	65	..	...	..	...	..	...	..	...
Ohio	225	Purchased	Hand	8	120	..	...	..	...	8	90	..	...	..	...	..	...	..	...
Ohio	525	Steam	Stoker	8	164	8	151	9	140	8	120	8	163	..	...	9	140	..	...
Mississippi	465	Steam	Hand	12	*125	12	†85	..	...	8	†50	..	...	..	...	10	†80	10	†60
Chicago, Ill.	...	Steam	Hand	12	150	10	90	..	...	10	85	..	...	10	125	10	125	10	75
Denver, Colo.	375	Purchased	Hand Oil	12	190	8	110	..	...	9	75	..	...	..	...	..	...	..	...
Seattle, Wash.	150	Steam	Burners Oil	8	†175	8	†100	..	...	..	...	..	...	..	...	..	...	..	...
Portland, Ore.	110	Steam	Burners Oil	9	† 90	9	† 75	..	...	9	†70	..	...	..	...	..	...	..	...
San Francisco, Cal.	500	Steam	Burners	8	225	8	175	..	...	8	140	..	...	8	175	..	...	..	...

*Including house. †Including board. ‡Third class engineer at night.

trial plant in the same city pays watch engineers 45c per hour and firemen 47c per hour, both working twelve hours per day. Engineers and firemen in another Eastern city in hospitals receive $5 per day. At Niagara Falls municipal plants in Boston, the following wages are paid watch engineers: In railway plants, $45; in the army base plants, $45 to $52.50, and in two commercial plants, $40.

TABLE IV. SALARIES IN OFFICE BUILDINGS

Locality	Capacity in Kw. Basis	Source of Power	Method of Firing	Ch. Engr. Hr.	Ch. Engr. Sal.	Watch Engrs. Hr.	Watch Engrs. Sal.	Oilers Hr.	Oilers Sal.	Firemen Hr.	Firemen Sal.	Ch. Electricians Hr.	Ch. Electricians Sal.	Electricians Hr.	Electricians Sal.	Pipe Fitters Hr.	Pipe Fitters Sal.	Laborers Hr.	Laborers Sal.
New York City	1,200	Steam	Stoker	8	165	8	135	8	90	8	98	8	175	8	91	8	135	8	87
New York City	225	Steam	Stoker	..	240	..	120	..	...	..	100	..	...	..	120	..	...	..	...
New York City	750	Steam	Stoker	..	...	8	180	..	...	8	143	..	...	..	...	..	...	..	...
Philadelphia, Penn.	1,860	Steam	Hand	9	...	9	110	10	90	9	95	..	...	..	...	..	...	..	...
Pittsburgh, Penn.	1,200	Purchased	.....	..	225	8	162	8	140	..	...	8	200	8	216	8	235	8	105
Pittsburgh, Penn.	375	Steam	Stoker	8	135	8	125	9	90	..	...	8	135	..	...	..	...	..	...
Pittsburgh, Penn.	188	Steam	Stoker	8	200	8	132	..	...	8	98	..	...	..	...	..	...	8	90
Missouri	75	Purchased	Hand	12	145	..	...	..	...	10	*75	..	...	..	...	..	...	..	...
Detroit, Mich.	1,000	Steam	Stoker	..	275	8	130	..	...	8	105	10	155	10	130	..	...	..	...
Portland, Ore.	...	Purchased	.....	..	175	8	95	..	...	..	...	..	...	..	...	..	...	..	...
San Francisco, Cal.	...	Purchased	.....	9	150	9	100	..	...	..	...	..	...	..	...	..	...	..	...

*Only during heating season.

firemen are being paid 78c per hour. According to a table prepared by the Bureau of Labor Statistics of the United States Department of Labor, engineers receive $139.34 and firemen $120.52 per month in the bituminous-coal fields.

Table X gives data for watch engineers from a number of plants employing union men in one district of New York City. A certain office building in New York City paid $21 per week to watch engineers and $17 to firemen in 1914. Various raises were made until the

TABLE V. SALARIES IN INDUSTRIAL PLANTS

Locality	Capacity in Kw. Basis	Source of Power	Method of Firing	Ch. Engr. Hr.	Ch. Engr. Sal.	Watch Engrs. Hr.	Watch Engrs. Sal.	Oilers Hr.	Oilers Sal.	Firemen Hr.	Firemen Sal.	Ch. Electricians Hr.	Ch. Electricians Sal.	Electricians Hr.	Electricians Sal.	Pipe Fitters Hr.	Pipe Fitters Sal.	Laborers Hr.	Laborers Sal.
Central Massachusetts	450	Steam	Stoker	..	185	8	140	8	112	..	...	..	...	..	...	..	...	9	74
New York state	225	Steam	Hand	8	165	8	150	..	...	..	...	..	...	..	...	..	...	..	...
New York City	825	Steam	Hand	9	292	10	160	10	104	9	114	9	160	9	96	9	160	..	...
New York City	600	Steam	Hand	8	240	9	140	9	80	9	100	9	200	9	100	9	100	9	75
New York City	450	Steam	Hand	..	221	11	123	..	...	11	90	..	...	..	...	..	...	..	...
Philadelphia	182	Steam	Hand	..	130	9	95	..	...	..	...	..	...	10	65	..	...	..	...
Ohio	790	Steam Water Purchased	Stoker	12	156	12	124	..	...	12	110	..	...	..	...	..	...	..	...
Ohio	1,000	Steam	Stoker	8	212	12	180	..	...	12	180	..	...	..	...	..	...	..	...
Mississippi	470	Steam	Hand	11	225	11	120	11	90	11	90	..	...	..	...	..	...	11	90
St. Louis, Mo.	1,120	Steam	Stoker	..	210	8	156	8	120	8	136	..	...	..	...	..	...	..	...
Texas	56	Steam and Purchased	Hand	11	173	11	108	..	...	11	78	..	...	..	...	..	...	..	...
Chicago, Ill.	12,000	Steam	Stoker	10	325	8	166	8	125	8	135	10	300	8	192	8	156	8	104
Chicago, Ill.	95	Steam	Hand	8	140	..	...	..	...	..	...	..	...	..	...	..	...	..	...
Detroit, Mich.	1,120	Purchased	Stoker	8	225	12	198	..	...	12	180	..	...	..	...	..	...	..	...
Detroit, Mich.	400	Steam	Stoker	9	160	8	120	..	...	8	100	9	160	9	100	..	...	..	...
Minneapolis, Minn.	465	Steam	Stoker	10	160	10	120	..	...	10	114	..	...	..	...	10	144	10	108
Minneapolis, Minn.	800	Steam	Stoker and Hand	9	180	10	100	..	...	10	93	..	...	9	120	9	115	9	85
Seattle, Wash.	625	Steam	Hand	11	182	..	...	8	96	8	96	..	...	..	...	..	...	..	...
Portland, Ore.	95	Steam	Oil	9	163	9	117	..	...	..	...	..	...	..	...	..	...	..	...

The recent union agreement for municipal engineers in Boston was noted in *Power* for Aug. 19, 1919. The weekly salaries given there were as follows: For operating engineers at pumping stations, $37; on city ferries, $42; in public buildings with first-, second- and

TABLE VI. ENGINEERS' SALARIES IN NEW YORK CITY

No.	Kind of Plant	Hours Per Day	Days Per Week	Chief Engineer Basis of Pay	Chief Engineer Pay per Month	Watch Engineers Basis of Pay	Watch Engineers Pay per Month	Union	Remarks
35	Breweries	8	6	Weekly	213 to 425	Weekly	169	Yes	Double time for overtime.
8	Refrigerating plants	8	6	Weekly	248	Weekly	164	Yes	Double time for overtime.
8	Hotels	8	6	.....	...	Monthly	132	No	
6	Hotels	12	7	.....	...	and Weekly Monthly	115	No	
3	Theaters	8	6	Weekly	228	Weekly	139	Yes	Double time for overtime.
1	Theater	8	7	Weekly	139	Weekly	121	No	
..	Asphalt industry	8	5½	Weekly	213	Weekly	156	Yes	Double time for overtime.
1	Store	8	6	.....	...	Weekly	130	No	
1	Club	9	7	.....	...	Monthly	120	No	
1	Charitable institution	12	7	.....	...	Weekly	108	No	
2	Office buildings	9	6	.....	...	Weekly	127	No	
1	Laundry	9	6	.....	...	Weekly	173	Yes	

third-class plants, $37, $33 and $40, respectively, while engineers in charge in first-, second- and third-class plants receive $42, $37 and $33, respectively. Firemen and oilers in all plants receive $5 per day. All men work eight hours per day, six days per week. In non-union agreement has recently been signed providing for $42 for engineers and $33 for firemen per week.

A recent union agreement for engineers in the coal industry in Chicago has been signed. Under this the men work eight hours per day with a half holiday on

TABLE VII. ENGINEERS' SALARIES IN NEW JERSEY NEAR NEW YORK CITY

No.	Kind of Plant	Hours Per Day	Days Per Week	Chief Engineer Basis of Pay	Chief Engineer Pay per Month	Watch Engineers Basis of Pay	Watch Engineers Pay per Month	Union	Remarks
14	Breweries	8	6	Weekly	213	Weekly	137	Yes	Time and half for overtime.
7	Ice plants	8	..	.....	...	Weekly	156	Yes	Double time for overtime.
..	City and country plants	Not stated		Yearly	208	Yearly	150	Yes	Salaries quoted are minimums.
..	Several industrial plants	8	5½ & 6	.....	...	Daily	143 to 156	Yes	Two weeks' vacation with pay.

TABLE VIII. ENGINEERS' SALARIES IN CHICAGO

Kind of Plant	Hours Per Day	Days Per Week	Chief Engineer Basis of Pay	Chief Engineer Pay per Month	Watch Engineers Basis of Pay	Watch Engineers Pay per Month	Union	Remarks
Ice plant	8	..	Monthly	250	Hourly	...	?	80c per hour.
Breweries	8	6	Monthly	275 to 300	Hourly	...	?	89½c per hour.
Wood-working plant	8	6	.....	...	Hourly	146	Yes	Five hours' pay for washing boilers on Sunday.
Asphalt plant	8	..	.....	...	Hourly	...	?	87c per hour.
Office building	8	7	.....	...	Monthly	145	Yes	
Office building	12	7	.....	...	Monthly	125	No	
Laundry	9	5½	.....	...	Hourly	140 to 172	Yes	
Laundry	12	5½	.....	...	Weekly	108	No	
Railway plant	8	..	Monthly	213	Monthly	187	?	
Pumping plant	8	6	Monthly	250	Monthly	205	?	
Hospital	8	..	.....	...	Hourly	...	Yes	87½c per hour.
Steel plant	12	7	.....	...	Hourly	182	?	

TABLE IX. ENGINEERS' SALARIES IN ST. PAUL, MINNESOTA

Kind of Plant	Hours Per Day	Days Per Week	Chief Engineer Basis of Pay	Chief Engineer Pay per Month	Watch Engineers Basis of Pay	Watch Engineers Pay per Month	Union	Remarks
Packing houses	..	..	.....	...	Hourly	...	No	52½c to 62½c per hour.
Breweries	..	..	.....	...	Hourly	...	Yes	65c per hour.
City plants	..	..	.....	...	Hourly	....	...	Union Scale 70c per hour.
Cold storage plant	8	..	.....	...	Hourly	...	Yes	70c per hour.
Cold storage plant	9 to 10	..	.....	...	Monthly	175	Yes	
Store	..	..	Yearly	250	Hourly	...	Yes	75c per hour.
Store	..	..	.....	...	Hourly	...	Yes	70c per hour.
Small industrial plant	9 to 10½	..	.....	...	Monthly	110	No	
Railway shop	8	..	Monthly	115 to 151	Hourly and Monthly	93 to 110	No	

Saturday. Watch engineers receive $38 a week for day shifts, and $40 for night shifts. Sundays and holidays they receive $12 for the day shift and $14 for the night shift. Overtime is paid at $1.25 per hour on weekdays and $2.25 per hour on Sundays and holidays. Hoisting engineers get $35 and trolley engineers $33 per week.

TABLE X. SOME UNION WATCH ENGINEERS' SALARIES IN NEW YORK CITY

Kind of Plant	Hours per Day	Days per Week	Basis of Pay	Pay per Month
Central station	8	7	Weekly	$167
Factory	8	5½	Weekly	156
Factory	8	6	Weekly	176
Factory	8	6	Weekly	182
Factory	8	7	Weekly	167
Factory	8	7	Weekly	182
Factory	12	6	Weekly	146
Factory	12	6	Weekly	156
Office building	8	6	Weekly	173
Hospital	8	7	Weekly	134
Ice companies	8	7	Weekly	152
Lumber	8	5½	Weekly	156
Lumber	8	6	Weekly	156
Railroad, stationary	8	7	Weekly	177
Dry dock	8	6	Weekly	167
City employees	8		$6 per day	
Shipyards			80c per hour	

In Bakersfield, Calif., the union scale provides for eight hours per day with time and one-half for overtime. Operating engineers receive $6 per day in freight yards, canneries, laundries and wineries, $6.50 in distilleries and $8 in schools, hotels, etc. In electric, gas and ice

TABLE XI. WAGE SCALE FOR LICENSED MARINE ENGINEERS

	A	B	C	D	E
Chief engineer	$387.50	$346.25	$332.50	$318.75	$305.00
First assistant engineer	241.25	235.00	228.75	222.50	216.25
Second assistant engineer	212.50	206.25	200.00	193.75	187.50
Third assistant engineer	188.75	182.50	176.25	170.00	163.75
Fourth assistant engineer	165.00	158.75	.....	.....	.....
Junior engineer	135.00	.....	.....	.....	.....

plants chief engineers get $7, watch engineers $6, and apprentices $5 per day, while on dredges, chiefs get $8.66 and watch engineers $7.60. In Oakland, Calif., the union scale gives $7.04 per day in shipyards. In Baltimore, Md., union rate is 75c per hour for six days of

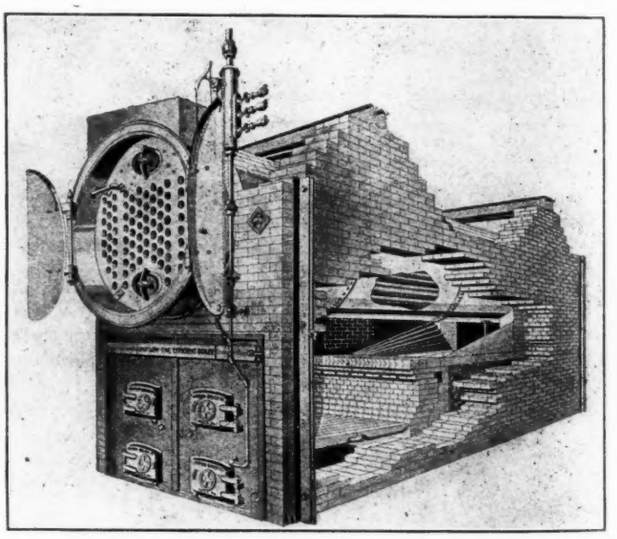
TABLE XII. TONNAGE OF SHIPS FOR WAGE CLASSIFICATION

Classes	Single Screws	Twin Screws
A	Over 20,001	Over 15,001
B	12,001 to 20,000	9,001 to 15,000
C	7,501 to 12,000	5,501 to 9,000
D	5,001 to 7,000	3,501 to 5,500
E	Below 5,501	Below 3,501

eight hours each for operating engineers. Table XI shows the present wage agreement between the shipowners and the Marine Engineers' Union, while Table XII shows the tonnage of the various classes of ships referred to in Table XI.

Uniflow Setting for Boilers

It has been the custom, and is now, to a large extent, for the purchaser of a steam boiler to engage the local brickmason to put up the brickwork and practically to design the furnace. The result of such furnace construction has been that insufficient space has been allowed for combustion to take place, and this has led to uneconomical boiler operation. To overcome this fault, the uniflow furnace and setting have been designed, and complete drawings are furnished with each boiler installation by the Uniflow Boiler Co., Philadelphia, Pa. In this design of furnace setting air is introduced



PART SECTIONAL VIEW OF SETTING

through the bridge-wall in such a way that it is not preheated, and smokeless combustion and secondary ignition of the gases from the fuel result. By the use of an inverted arch extending from the bridge-wall toward the rear of the boiler, the gases are made to impinge against the shell with a scouring action, making that portion of the shell which has previously been insulated with a film of dust a part of the effective beating surface.

The brickwork is so assembled as to prevent the internal expansion from disturbing it, and the red brick is retained as the structural element of the setting, leaving the firebrick to function as the heat insulating element alone. With this type of setting the boiler is suspended from I-beams supported on the red brickwork.

Rubber Slugs for Cleaning Condenser Tubes

The number of inquiries *Power* receives and the discussion in its columns about cleaning condenser tubes shows that interest in the subject is keen—and naturally so. It does not take long for condenser tubes to become so heavily coated with scum that the heat transmission through them decreases sufficiently to seriously impair the vacuum. In steam-turbine operation loss of vacuum increases the machine's water rate.

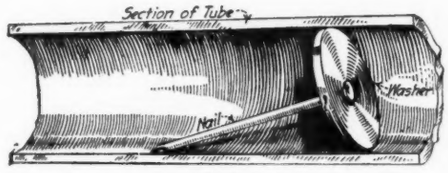


Fig. 1

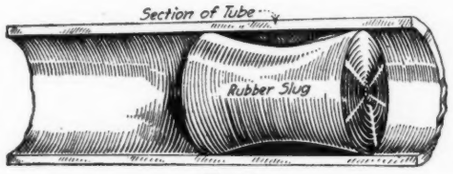


Fig. 2

WASHER AND SLUG FOR CLEANING SLIME FROM CONDENSER TUBES

Several months ago many engineers told how they cleaned condenser tubes. For tubes that scale the most satisfactory practice seems to be the use of a mechanical cleaner similar to those used in cleaning boiler tubes. But for freeing tubes of the scum that collects in them many devices are in use. One that is quite widely applied consists of a leather or rubber washer of diameter to fit the tube and through the center of which a nail is driven. Many of these are made and one placed in each tube when about to clean the condenser. The nail holds the washer almost on edge. Compressed air is used to force the washer through the tube.

The engineers at the Fifty-ninth Street and Seventy-fourth Street Stations of the Interborough Rapid Transit Co., New York City, of which Walter S. Finley is superintendent of motive power, find that the washer does not make contact all around the surface of the tube and therefore does not thoroughly clean off the scum. So they now have in use many hundreds of rubber slugs of the shape shown in Fig. 2. These are placed, one in each tube, and blown through by means of compressed air. The results are highly satisfactory. The slugs are of rubber that is neither very hard nor very soft.

The following description of a device for applying acid to dissolve scale from condenser tubes appeared in a recent issue of *Engineering*, London.

Within recent years the objections which many engineers had to the introduction of chemicals, on account of their fear of corrosion, have been largely overcome, and in quite a number of power plants acid or caustic is now regularly used for cleaning the condensers. In some stations it is still the practice to paint the interior surfaces of the iron casing with acid-resisting enamel before starting cleaning, but this protection is not really needed unless an unnecessarily strong acid is used.

It is obviously desirable to keep the chemical solution in motion while it is attacking the scale in the tubes, and various makeshift devices have been designed and used by engineers for this purpose. A simple arrangement has, however, recently been brought out for the purpose by the Mirrlees-Watson Co., of Glasgow, and is shown in Fig. 3. It takes the form of a steam ejector combined with a circulating pipe and can be fitted on existing handhole doors or to special facings on the end covers of the condenser. The ejector is shown at *A* and is supplied with live steam from any convenient source. The ejector discharges into the lower part of the condenser and is connected on the inlet side with the upper part by means of the external pipe shown.

In operation the condenser is fitted up with clean water and the quantity required for the purpose noted. The two valves *E* and *D* are then opened and steam turned on to the ejector. Water is then sucked through the bell-mouth *G* and discharged through the perforated cone *F*. When circulation is thus established a quantity of the cleaning liquid sufficient to form the required solution is poured into the funnel *B*, and on opening cock *C* this liquid is drawn in and mixed with the hot water circulating in the condenser. The condensation of the steam used in the ejector naturally causes a gradual dilution of the solution, while the chemical reaction neutralizes the acid or alkali, and this has to be counteracted by the addition of more chemical. The ejector must be temporarily shut off if the temperature rises too high.

The nature and quantity of cleaning liquid required and the length of time necessary for the solution to be circulated in the condenser will depend on the character and amount of the deposit. Caustic soda is the best cleanser when the deposit is of a greasy or muddy nature. A 1 per cent. solution—1 lb. of caustic soda to each 100 lb. or 10 gal. of water—should first be used in the condenser, and may be increased gradually to a maximum of 7 per cent. Dilute hydrochloric acid is the most suitable cleanser when the deposit is in the form of a hard scale composed of sulphate or carbonate of lime or magnesia. A 5 per cent. solution may be tried in the condenser at the outset and increased in bad cases to a maximum of 40 per cent., which limit must not be exceeded. In this way a condenser can be cleaned in from six to eight hours unless it has been allowed to get into a very bad condition, and it is only necessary thoroughly to flush it out with a slightly alkaline solution if acid has been used or with water to wash out the remains of caustic, to be able to set the plant to work again. Thus the cleaning can quite conveniently be carried out during the slack time of a week-end.

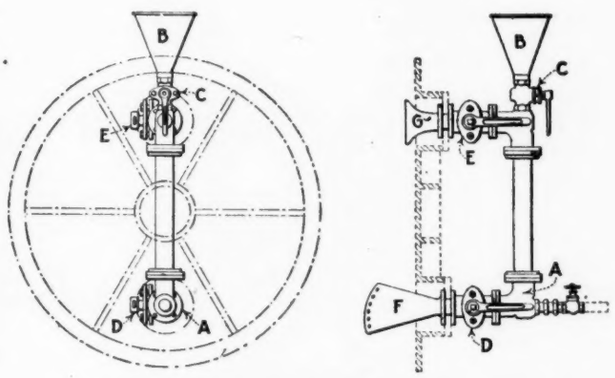
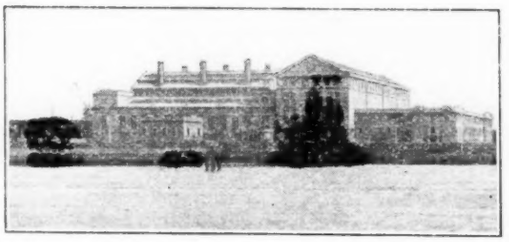


FIG. 3. ARRANGEMENT FOR FEEDING ACID TO CONDENSER TO CLEAN IT OF GREASE AND SCALE

There is only one other means of cleaning condenser tubes, of which we have any knowledge, that has been tried on a practical scale. It is the introduction, temporarily, of sand into the circulating system. Such a scheme has been tried out in South Africa, as mentioned in our "Notes" column recently, and in view of the experience of steamers in the East, just referred to, the idea merits consideration. The disadvantage of the sand method is, of course, that the pump impeller and circulating-valve seatings would be eroded, but if the ejector system could be adopted to handle gritty water and abrasive with a specific gravity approaching unity could be obtained, it appears as if this system of cleaning might appeal to engineers who are still unwilling to use acid for fear of continued corrosion.

The Newport Electric Power Station of the Melbourne Suburban Railway System*

By E. P. GROVE



AFTER some years of deliberation the electrification of the entire suburban railway system of Melbourne was decided on and has now been put into operation. The plan adopted provided for the direct-current overhead-wire system. Power in the form of three-phase alternating current at 20,000 volts is transmitted from the general generating station to substations, where it is converted to direct current and delivered to the contact wires over the tracks.

The site of the central power station at Newport was selected principally because of the convenient supply of condensing water. The intake for cooling water is on the west side of the River Jarra retaining wall, while the discharge is turned into a small dock on the east side of the retaining wall and so into the river without mixing with the incoming water.

The generators deliver three-phase current at 3300 volts between phases and 25 cycles per second, which is stepped up to 20,000 volts by static transformers for transmission to the substations.

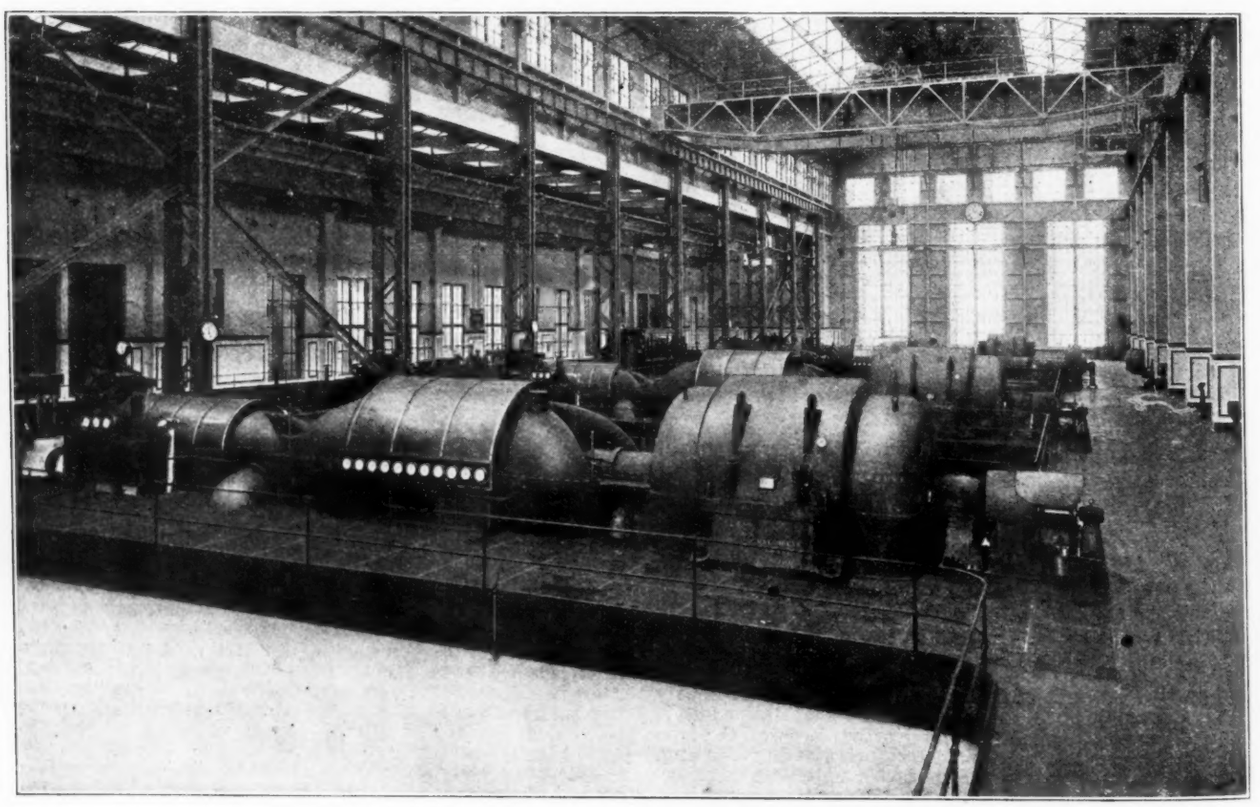
There are six turbo-generator units, each having a normal rated capacity of 10,000 kw. with a maximum continuous output of 12,500 kw. at 0.95 power factor with a maximum temperature rise of 45 deg. C. from an intake air temperature of 25 deg. C. Steam is supplied at 210 lb. per sq. in. pressure and superheated to a total temperature of about 600 deg. F.

The turbine room is 300 x 76 ft. and is joined by the pumphouse, which is 275 x 31 ft. Two boiler houses each 170 x 70 ft. run at right angles to the pumphouse and turbine room, and between the boiler houses are the tankhouse, stores, etc. On the other side of the turbine room is a building containing transformers, batteries, etc., while still farther north of this is the switch-house, control room and administrative offices.

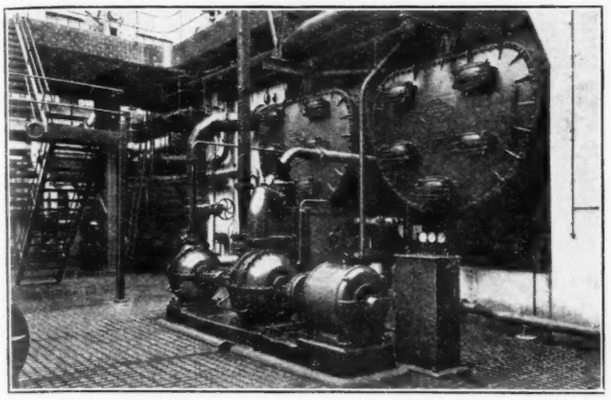
Circulating water is taken in through two canals which lead to the screen pits. Here the first screens are stationary, consisting of bars placed approximately 3¾ in. apart. Beyond these are four revolving screens of the conveyor type, each driven by a 5-hp. induction motor. These screens have a ⅝-in. mesh. There are two motor-driven centrifugal pumps to provide water at 50 or 60 lb. pressure for washing the screens. A 7½-ton crane is provided for lifting the screens for repairs.

There are 12 Babcock & Wilcox marine-type boilers in each house, arranged in two rows of six each with the firing floor between. Each of the 24 boilers has

*Abstract of an article in the *Commonwealth Engineer*, Australia.



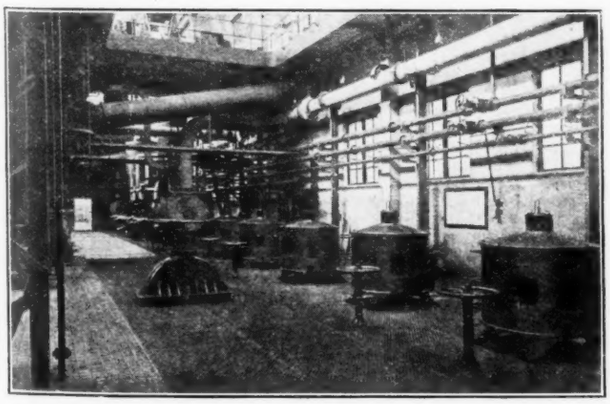
VIEW OF TURBINE ROOM SHOWING THREE OF THE MAIN UNITS



TWIN CONDENSERS WITH EXTRACTING PUMPS

6725 sq. ft. heating surface and 1043 sq. ft. superheating surface with 168 sq. ft. grate surface. The boilers are in pairs with individual superheaters and economizers, but each pair has a common fan and stack. Under each boiler is an ash bunker having a 12-hour full-load capacity. Below the ash bunkers is a portable crusher which moves on a narrow-gage track. This crusher discharges into a pipe through which the ashes are drawn by air suction to elevated receivers at the end of the boiler houses. Two exhausters for this suction ash-removal system are installed in the basement of each boiler house. The elevated ash receivers discharge by gravity into cars on the track carrying the coal-supply cars.

Coal is brought in hopper-type bottom-dump cars, over a single track from the receiving sidings, to hoppers at the end of the boiler houses. The empty cars continue in the same direction to the departure sidings, thus requiring little or no shunting. From the track hopper the coal drops through a crusher—or if desired around the crusher—to any one of three bucket conveyors as required. Two of these conveyors carry the coal to the bunkers on either side of the boiler house, while the third carries it to a storage yard extending from the end of the boiler house. This same third conveyor returns through a tunnel under the storage ground and is equipped with a traveling filler so that it may be used to reclaim the stored coal. A traveling jib crane rides on the gantry supporting the coal-storage conveyor and may be used to spread storage coal or to help reclaim it. This crane may discharge into an auxiliary hopper over the main-track hopper. Coal from the boiler-house bunkers goes by gravity chutes to the boiler hoppers, which feed the Babcock & Wilcox chain-grate stokers.

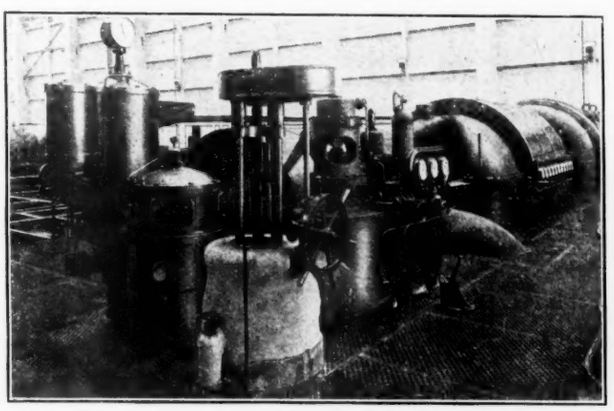


CIRCULATING PUMP MOTORS IN BASEMENT OF PUMP HOUSE

A 10-in. steam header from each row of boilers delivers into a receiver located in the basement of the pumphouse, and from the receivers the steam goes to the turbines. The four receivers are interconnected by a 10-in. main, so that the entire system is very flexible.

The basement of the pumphouse, which is between the engine room and the boiler rooms, contains the feed pumps—two reciprocating and two turbine-driven centrifugal pumps for each boiler house—the high-pressure pumps for fire and for boiler washing, the feed-water heaters and the condenser circulating pumps. The circulating pumps are motor-driven centrifugal pumps with a capacity of 14,000 gal. per min. each at 500 r.p.m. and are located in a pit in the center of the pumphouse so as to be submerged even at low tide. The motors are on the turbine-room basement level. All the circulating pumps deliver into a common 44-in. diameter main which runs the entire length of the turbine-room basement.

The turbine room contains six 10,000-kw. turbo-generators on foundations carried down to the basement Under each turbine are two twin surface condensers each having 22,000 sq. ft. of tube surface. Alongside the condensers are the kinetic, air and water, extraction

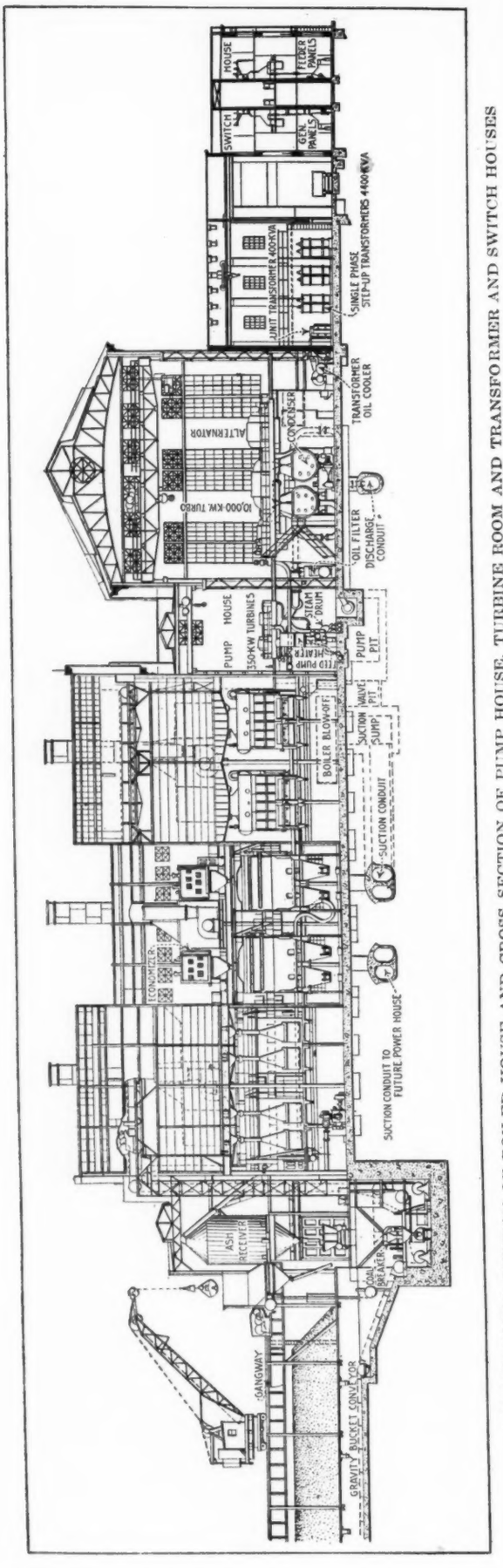


STEAM END OF 10,000 KW. TURBINE

pumps. The system is designed to give a 28¾-in. vacuum with a 30-in. barometer, when handling 120,000 lb. of steam per hour. The turbine-room basement also contains the turbine oil coolers, the oil filters, the oil coolers for the step-up transformers, the circulating pumps for the air washers and alternator ventilating fans.

The main turbines are of the Parsons reaction type built by C. A. Parsons & Co., Ltd. The turbine cylinders are divided, the high-pressure cylinder being single flow, while the low-pressure is double flow with center admission. The governing is of the usual Parsons "Gust" type, operated from a cam on the vertical governor spindle. The steam chest is not rigidly connected to the turbine cylinder, thus allowing a much more uniform distribution of metal than in the usual type where the steam chest is mounted on the cylinder. Lubrication is provided by two rotary pumps driven from the governor spindle with a steam-driven auxiliary oil pump for starting and stopping.

The alternator is of Parsons design, giving three-phase current, 3300 volts, 25 cycles per second at 1500 r.p.m. The exciter is of the Parsons four-pole type and is fitted to an extension of the alternator shaft. The ventilation of the alternators is effected by means of fans on the rotor supplemented by motor-driven ventilating fans which draw air through a Sturtevant air washer and deliver it into a chamber in the concrete foundation



LONGITUDINAL SECTION OF BOILER HOUSE AND CROSS SECTION OF PUMP HOUSE, TURBINE ROOM AND TRANSFORMER AND SWITCH HOUSES

of the generator. The air is finally discharged by way of a brick uptake above the transformer chambers.

Two 350-kw. Parsons turbo-generators are installed on the turbine-floor level, in the pumphouse. These auxiliary machines generate three-phase current at 440 volts, 25 cycles, and are used to supply power for the various plant auxiliary motors when the main turbines are shut down. As they are expected to operate only for short periods, they are designed to run non-condensing.

All auxiliary motors in the station take three-phase current at 440 volts. Each main generating unit is equipped with a 400kv.-a. unit transformer fed from the 3300-volt line between the alternator and the step-up transformers, to supply this auxiliary current. In addition there are four 1000-kv.-a. transformers fed from the 20,000-volt busbars for the auxiliary service.

The auxiliary current is distributed from two switch boards, one at each end of the transformer house, in rooms opening onto the turbine floor. In each of these switchboard rooms there is a motor-generator set for charging the lighting and control batteries. These machines consist of a 102-hp. three-phase 440-volt induction motor and a 65-kw. d.c. 110-volt generator.

The auxiliary and step-up transformers for each generator are installed in a separate room in the transformer house. In each room is a traveling crane carriage on which can be hung a 15-ton hoist. This carriage can travel, through openings in the wall, over the railroad track between the transformer house and the switchhouse. These openings are normally closed by sheet-steel doors.

The switchhouse is a brick and concrete building 299 x 44 ft. At one end are offices for the chief engineer and clerical force and at the opposite end is the control room. On the ground floor are the incoming and outgoing cables, potential transformers and isolating switches. On the second floor are the oil switches. The equipment for each generator is in a separate brick chamber, and the oil switches are open to the outside air through vents so as to exhaust any explosive gases. The windows on the oil-switch floor are left unglazed so as to minimize the damage from possible explosions. All oil switches are electrically controlled.

The control room is on the first-floor level with a railed gallery around three sides so that there is no necessity for admitting visitors to the control floor. In the center of the room is the control engineer's desk, which is equipped with telephones to all substations as well as to all parts of the central station. Around the room are the control switchboards, in front of which are the telegraphs by which instructions are sent to the turbine operators and boiler-room attendants. In front of these again are the automatic voltage regulators and loud-speaking telephones for communication to the turbine engineers. On one wall is a complete system diagram arranged for mechanical record of all switching operations.

New Coal Deposit In Chile

An article published recently in the Chilean newspaper, *Las Ultimas Noticias*, gives particulars of several new coal deposits which have been found in southern Chile. The first of these is stated to be near La Union. The quality of the coal is considered to be very good, and machinery is being installed for the exploitation of the deposit. It is estimated that 40,000,000 tons can be extracted, and a special railway is being built to Rapallo station.

Fusibility of Ash From Eastern Coals*

By W. A. SELVIG, O. C. BROWN AND A. C. FIELDNER
Of the Bureau of Mines

THE Eastern coal province, which includes the anthracite regions of Pennsylvania and Rhode Island, the Atlantic Coast region of Virginia and North Carolina, and the great Appalachian region, contains the best-known and most extensively mined coals in the United States.

Previous papers[1] gave a description of the standard gas furnace method used by the Bureau of Mines in making ash-fusibility tests, a discussion of the relation of fusibility tests to clinker formation, and tables giving results obtained for West Virginia, Pennsylvania and Mid-Continent coals. This paper includes a table giving the results obtained for all coals tested from the remaining states of the Eastern coal province and includes coals from Ohio, Eastern Kentucky, Virginia, Maryland, Tennessee and Alabama. No coals from Rhode Island, North Carolina or Georgia are represented. Rhode Island and North Carolina are of little commercial importance as coal producers.

The samples represented are standard mine samples collected by representatives of the Bureau of Mines, the United States Geological Survey, or by the various state geological surveys, according to the methods used by the Bureau of Mines.[2]

The point taken as the softening temperature is that at which the ash, when molded into solid triangular pyramids ¾ in. high and ¼ in. wide at the side of the base and mounted in a vertical position, has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+ 3010), and used as such in figuring the average values for the mine from which the average values of the beds were com-

For convenience in discussion the order of fusibility of coal ash from the various coals of the country may be divided into three groups as follows:

Class 1: Refractory ashes, softening above 2600 deg. F. Class 2: Ashes of medium fusibility softening between 2200 and 2600 deg. F. Class 3: Easily fusible ashes, softening below 2200 deg. F.

The coals of Ohio which were tested gave ash of medium fusibility; the average values of the different beds come mainly in Class 2. The softening temperature of the ash from coals of eastern Kentucky and Virginia cover a wide range of fusibility from readily fusible ashes coming in Class 3, to refractory ashes coming in Class 1. Many of the coal beds of Maryland which are represented give coal having a refractory ash coming in Class 1 or in the upper part of Class 2. The coals tested from Tennessee and Alabama come mainly in Class 2, giving ash of medium fusibility, though both Class 1 and Class 3 are represented.

State, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Deg. F.	Ash in Dry Coal, Average Per Cent.	Sulphur in Dry Coal, Average Per Cent.
Ohio					
Anderson (Bakerstown) Bed	1	1	2120	10.86	3.92
Lower Freeport Bed	8	16	2280	9.55	2.95
Lower Kittanning Bed	4	4	2120	9.24	5.72
Mahoning Bed	1	1	2040	6.59	3.67
Meigs Creek (Sewickley) Bed	5	5	2330	13.02	4.23
Middle Kittanning Bed	6	6	2450	8.00	1.86
Pittsburgh (No. 8) Bed	10	14	2210	8.47	3.58
Uniontown Bed	2	2	2230	16.10	3.58
Upper Freeport (No. 7) Bed	10	14	2280	8.48	3.09
Washington Bed	1	1	2520	21.90	2.98
Waynesburg Bed	4	4	2400	15.92	3.15
Eastern Kentucky					
Alum Bed	1	1	2940	4.37	.61
Elkhorn Bed	8	22	2470	3.83	.68
Fire Clay (Dean, or No. 4) Bed	9	25	+2790	5.35	.82
Flag (No. 7) Bed	1	4	2880	7.52	.83
Harlan Bed	3	8	+2700	3.94	.85
Hazard (Haddix, or No. 6) Bed	1	4	2460	8.56	.79
Hickory Bed	1	4	2340	5.37	1.07
Jellico Bed	1	4	2460	6.92	1.56
Kellioka (C) Bed	1	1	2230	2.21	.49
Lower Bolling Bed	1	1	2880	11.65	1.01
Lower Hignite Bed	1	3	2440	4.57	1.10
Lower Standiford Bed	1	1	2260	5.24	1.81
Mason Bed	3	11	2320	3.93	1.14
Miller Creek (No. 1) Bed	6	13	2160	4.23	1.90
Poplar Lick Bed	1	4	2670	5.30	1.05
Rawl (Gas, or No. 2) Bed	2	2	+2680	7.53	1.90
Straight Creek Bed	4	16	2110	3.40	1.17
Thacker Bed	1	1	2430	4.42	1.39
Upper Hance Bed	1	4	2330	4.74	1.61
Virginia					
"B" Bed	1	1	2420	17.73	2.21
Big Bed	3	3	2420	19.98	.57
Big A No. 2 Bed	1	2	2320	6.34	.60
Big Town Hill Bed	1	2	2240	11.84	.48
"C" Bed	1	2	2210	10.26	1.40
Clintwood Bed	1	1	2670	3.26	.87
Duncan Bed	1	1	2160	6.65	.88
Glamorgan Bed	1	2	2160	5.86	1.22
Imboden Bed	2	3	2420	11.47	1.56
Jawbone Bed	1	1	2240	19.86	1.03
Kennedy (Widow Kennedy) Bed	5	8	2190	7.95	1.09
Large Bed	5	7	+2880	20.19	.62
Little Bed	1	1	+3010	21.29	.49
Little Town Hill Bed	1	2	2440	8.40	.56
Lower Banner Bed	3	8	2280	6.37	.72
Lower Bolling Bed	1	1	2720	8.74	1.12
Meadow Bed	1	2	2480	12.92	.62
Milner Bed	1	1	2120	5.89	1.69
Mohawk Bed	1	2	2160	3.49	1.32
No. 4 Bed	1	3	2180	6.58	.49
Pardee (Parsons) Bed	1	2	2460	8.04	1.59
Pocahontas No. 3 Bed	5	28	2420	4.26	.54
Pocahontas No. 5 Bed	1	1	2090	5.19	.82
Red Ash Bed	1	2	2240	5.96	.64
Small Bed	1	1	+3010	42.98	.34
Splash Dam Bed	1	2	2720	5.77	.65
Upper Bed	2	2	+3010	29.72	.38
Upper Banner Bed	6	20	2420	6.43	.67
Maryland					
Bakerstown Bed	5	5	+2560	10.26	1.70
Bluebaugh Bed	3	3	+2770	12.99	1.63
Brush Creek Bed	1	1	2470	9.61	1.26
Clarion (Parker) Bed	2	2	2280	9.61	2.42
Franklin Bed	1	1	2410	8.48	1.36
Gallitzen Bed	3	3	2140	12.15	3.33
Grantsville Bed	1	1	2490	8.23	1.23
Little Pittsburgh Bed	1	1	+3010	7.95	1.18
Lower Freeport Bed	1	1	2150	20.51	4.11
Lower Kittanning Bed	15	24	2440	10.76	2.26
Mercer (Mt. Savage) Bed	3	3	+2620	18.14	3.28
Pittsburgh (Big) Bed	6	20	+2930	7.67	1.03
Quakertown Bed	1	1	+3010	17.03	2.92
Split-six Bed	1	1	2220	12.42	2.55
Upper Freeport Bed	5	5	2500	10.72	2.03
Upper Kittanning Bed	2	2	+3010	9.50	.86
Upper Sewickley (Tyson) Bed	6	9	+2840	6.65	1.09
Waynesburg Bed	1	1	2410	13.75	2.58
Tennessee					
Angel Bed	1	1	2160	5.80	1.94
Battle Creek Bed	2	3	2520	9.68	1.52
Billygoat Bed	1	1	2600	3.26	1.12
Blue Gem Bed	14	23	2100	3.32	1.34
Bon Air No. 2 Bed	8	21	2180	10.27	3.24
Castle Rock Bed	2	2	2260	10.78	2.68
Catoosa Bed	1	3	2250	7.11	2.59
Coal Creek Bed	22	53	2260	6.30	2.37
Frozen Head Bed	1	1	2580	6.92	.92
Grassy Ridge Bed	1	1	2470	3.75	1.87
Hooper Bed	1	1	2330	2.58	.69
Jellico Bed	14	38	2350	4.95	1.87
Jordan Bed	3	6	2320	3.33	.90

*Published by permission of the Director, U. S. Bureau of Mines.

[1] Selvig, W. A.; Fusibility of Ash from West Virginia Coals," *Power*, Oct. 15, 1918, p. 566-7; *Chemical and Metallurgical Engineering*, Vol. 19, No. 12, 1918, pp. 826-8.

Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash from Pennsylvania Coals," *Power*, June 10, 1919, p. 897; *Chemical and Metallurgical Engineering*, Vol. 20, No. 12, 1919, p. 629.

Selvig, W. A., Ratliff, W. C., and Fieldner, A. C.; "Fusibility of Coal Ash," *Power*, Apr. 1, 1919, p. 479-80; *Chemical and Metallurgical Engineering*, Vol. 20, No. 6, 1919, pp. 274-6.

For complete tables giving results obtained for each mine tested see: Selvig, W. A., "Fusibility of West Virginia Coal Ash," *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16; Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash from Pennsylvania Coals," *Coal Age*, Vol. 15, No. 24, 1919, pp. 1086-9; Selvig, W. A., Ratliff, W. C., and Fieldner, A. C., "Fusibility of Ash from Coals Found in the Interior Province," *Coal Age*, Vol. 15, No. 16, 1919, pp. 698-703.

[2] Holmes, J. A.; "The Sampling of Coal in the Mine," Technical Paper 1, Bureau of Mines, 1911, 18 pp.

State, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Deg. F.	Ash in Dry Coal, Average Per Cent.	Sulphur in Dry Coal, Average Per Cent.
Kelley Bed	2	2	2530	7.63	1.33
Lower Dean Bed	1	1	2340	3.69	.72
Mingo Bed	6	19	2390	4.25	1.27
Monarch Bed	1	4	2320	11.29	2.77
Morgan Springs Bed	2	2	2260	11.05	3.46
Mud Slip Bed	1	1	2640	4.21	.92
Nelson Bed	3	7	2340	18.73	1.11
No. 4 Bed	2	5	2220	9.08	3.62
No. 10 Bed	1	3	2150	11.42	3.14
Old Eagle Bed	1	1	2290	3.57	1.39
Old Etna Bed	1	1	2140	2.63	.76
Paint Rock Bed	6	6	2420	6.03	1.74
Poplar Lick Bed	4	11	+2610	8.36	1.84
Red Ash Bed	4	13	2570	6.13	1.13
Rex Bed	2	10	2230	5.59	1.07
Richland Bed	3	6	2590	10.53	.92
Rich Mountain Bed	5	12	2370	3.03	1.29
Sandstone Parting Bed	1	1	2380	10.34	1.26
Sewanee Bed	22	40	2460	10.02	1.20
Soddy Bed	5	9	2580	6.78	1.16
Upper Dean Bed	1	3	2290	12.02	2.29
Walden Ridge Bed	2	2	2580	8.17	.92
Alabama					
Black Creek Bed	3	12	2530	3.31	.83
Clark Bed	2	6	2350	8.68	1.06
Coal City Bed	1	3	2250	4.35	1.10
Gholson Bed	2	7	2240	6.64	.73
Harkness Bed	3	8	2460	11.51	1.57
Helena Bed	2	6	2420	8.91	.46
Jagger Bed	3	8	2690	9.81	.67
Jefferson Bed	1	4	2120	7.45	2.80
Mary Lee (Big) Bed	4	14	2830	9.90	.74
Maylene Bed	2	5	2350	8.29	.45
Montevallo Bed	1	4	2330	7.24	.76
Nickel Plate Bed	1	5	2620	4.73	.75
Pratt Bed	1	7	2430	5.49	1.59
Thompson Bed	3	10	2230	8.85	.52
Upper Straven Bed	1	2	2340	7.45	.88
Yellow Creek Bed	3	5	2370	13.90	2.91
Youngblood Bed	2	6	2130	8.62	1.08

Note: A plus sign (+) placed before a given value denotes that the true value is above that indicated.

Weighing Liquid Fuel in Engine Test

By J. S. A. Johnson*

In engine testing, while all observations should as a matter of course be recorded with the greatest care, the items of vital importance are the quantity of fuel used in a given time and the corresponding mechanical energy developed.

Very often the suction pipe, or flexible tube, is supported as shown and allowed to dip into the fuel, the lower end extending to *C*. The fuel tank should have a cover that fits closely around the suction pipe to prevent evaporation of light fuels, allowing only enough air to maintain atmospheric pressure inside the tank. With this arrangement it becomes necessary that the fuel tank rest permanently on scales unless an auxiliary supply be provided for starting up the engine and running it until the time for beginning the test. Even with the auxiliary supply there would always be some uncertainty regarding the amount of fuel that would drain back into the tank during the period of disconnecting from the system and removal for weighing.

Any arrangement of this sort, however, is unsatisfactory on account of the allowance that has to be made for the weight of the volume of fuel displaced by the suction pipe, considered as solid, between the initial and final fuel levels, 1-1 and 2-2; and in several reports of tests that have come to the attention of the writer, apparently no such allowance was made or even thought of.

That allowance must be made is evident from a consideration of the diagram. Neglecting the volume of the pipe material between the initial and final fluid levels *A* and *B*, the total downward pressure at the level *B* at the beginning of the test is greater than that at *A* by an amount equivalent to the height of a column of fluid between the levels *A* and *B*, the pressure inside the pipe at *A* as well as outside being atmospheric at the beginning of the test. At the end of the test the total downward pressure at *B* is only atmospheric over the entire section. Therefore, the fuel in the pipe between the levels *A* and *B* is supported by the scales at the beginning of the test, but not at the end. *Apparently*, then, an amount of fuel has been drawn out equal to the *total* volume between the levels *A* and *B*, and the scales will accordingly register a difference equal to the weight of this total volume, while as a matter of fact only that liquid outside the pipe between these sections has been removed. The actual weight of fuel used must therefore be calculated by subtracting from the difference recorded by the scales, the weight of a volume of the liquid equal to the volume of the dimensions of the

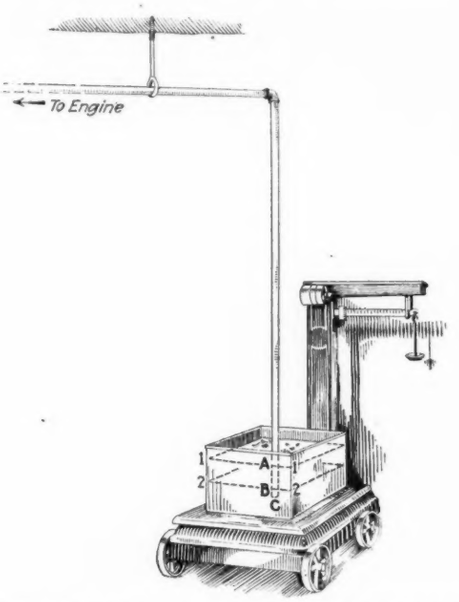


DIAGRAM OF LIQUID-FUEL-WEIGHING APPARATUS

suction pipe, considered as of solid cross-section, between the levels *A* and *B*.

As an illustration, let is be assumed that a suction pipe of ½-in. diameter be used, while the diameter of the fuel tank is 4 in., the cross-section of each being uniform and the axes of both pipe and tank being vertical. The sectional areas would be in the ratio of ¼ to 16 or 1 to 64, and the actual weight of fuel would be calculated from the apparent, W_a, or that recorded by the scales, by the expression,

$$W_a \times \frac{64-1}{64} = \frac{63\,W_a}{64}$$

If the diameter of the suction pipe were one inch, the correct weight would be

$$W \times \frac{16-1}{16} = \frac{15}{16}$$

The difficulty could be obviated by attaching a flexible suction connection near the bottom of the tank instead of extending into the liquid from above, but the writer has found that a carefully calibrated vertical pipe tank, with gage-glass and graduated scale, gives satisfactory results.

*Professor of applied mechanics and experimental engineering, Virginia Polytechnic Institute, Blacksburg, Va.

Despite the efforts made to convince the Senate Committee on Appropriations that the consumers of coal are entitled to statistics which would enable accurate estimates of the country's coal needs, it is practically assured that the committee will not approve the $40,000 appropriation asked for that purpose.

The Electrical Study Course—Alternators in Parallel

Comparisons are made by hydraulic analogies, when direct-current generators are operating in parallel with the conditions when alternators are operated in parallel. Conditions that must be met for alternators to operate successfully in parallel are discussed, and the method of changing the load from one alternator touched upon.

WHEN attempting to operate alternators in parallel, it is necessary to observe the same precautions as in the case of direct-current generators, namely, that their voltages are of the same value and in the same direction. The latter of these requirements is more difficult of fulfillment in the case of alternators, since the direction of their voltages is continually changing. The only conditions under which it is possible is that they be connected together at some instant when the voltages are at exactly the same period of a cycle and that their prime movers then drive them at precisely identical speeds. To make clear the relations that exist, it will be convenient to refer back to the parallel operation of direct-current generators.

Suppose that two such generators are connected together as illustrated in Fig. 1. When the polarities are as shown, each generator will deliver half of the power if they both generate the same voltage. Suppose now that the generators have been connected with opposite polarities, as shown in Fig. 2. A very large current would then instantaneously flow through the machines by way of the leads A and B, but no current would be delivered to the load through the leads C and D. As a matter of fact, the condition existing would be a short-circuit. We might illustrate the conditions of Figs. 1 and 2 by hydraulic analogies, as in Figs. 3 and 4. In Fig. 3 we have two centrifugal pumps that are rotated in the same direction and deliver the same pressure. The flow of water will be from a and through P_1 to the pipes p, and thence by way of P_2 back to b_1 and b_2. Suppose, now, that pump 2 were to be connected in reverse, as indicated in Fig. 4. It would in consequence pump water from a_2 to b_2, so that all the water pumped from b_1 to a_1 through pump 1 would pass through pump 2 and return to b_1 to go through the two pumps again and again. That is, water would merely be circulated around between the two pumps without causing any flow of water through the pipes p.

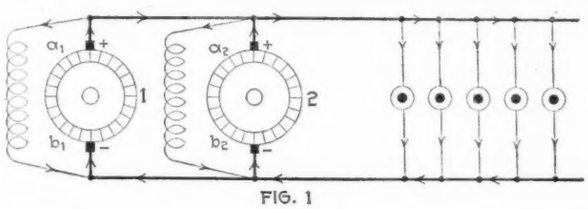


FIG. 1

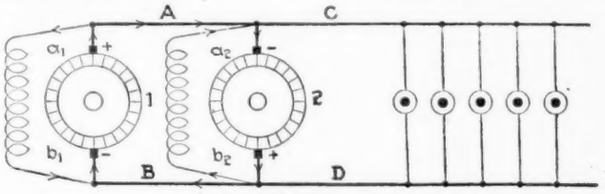


FIG. 2

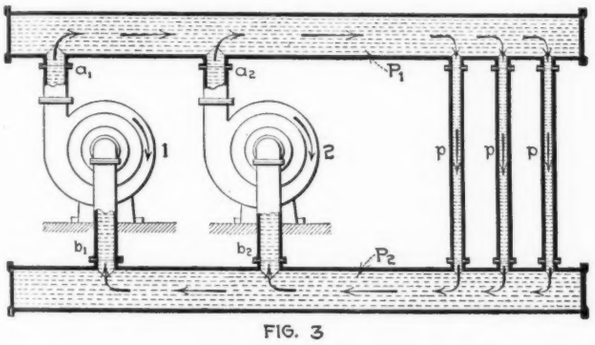


FIG. 3

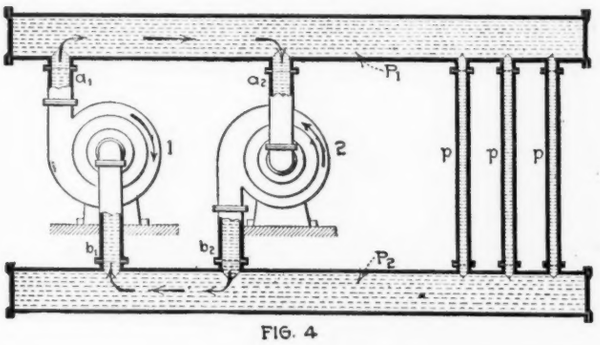


FIG. 4

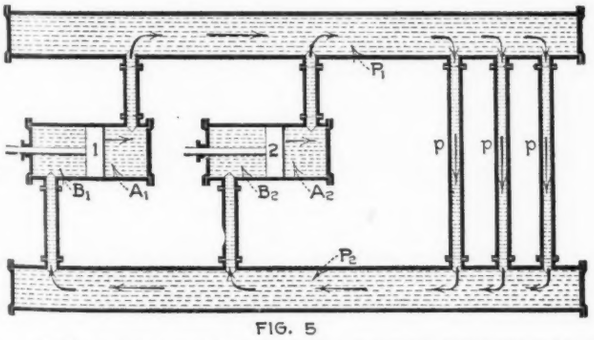


FIG. 5

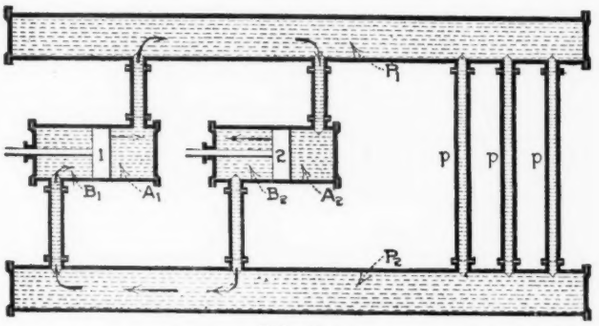


FIG. 6

FIGS. 1 TO 6. DIAGRAMS OF DIRECT-CURRENT MACHINES CONNECTED IN PARALLEL AND HYDRAULIC ANALOGIES OF DIRECT-CURRENT AND ALSO ALTERNATING-CURRENT MACHINES IN PARALLEL

Let us assume that the rotary pumps are replaced by plunger pumps, as illustrated in Figs. 5 and 6. If both pistons are traveling from left to right as indicated by the arrows in Fig. 5, water will be forced from A_1 and A_2 into P_1, through p to P_2 and back into B_1 and B_2. On the other hand, if piston 2 were moving from right to left when piston 1 is moving from left to right, as in Fig. 6, the space A_2 would increase as fast as A_1 de-

creased, and similarly B_1 would increase as fast as B_2 decreased. Consequently, whatever water is forced out of A_1 would flow into A_2 and all the water forced from B_2 would flow into B_1. The same conditions would exist on the return stroke, except that the flow would be in the reverse direction; that is, from A_2 to A_1 and from B_1 to B_2. The result is that the water is transferred from one pump to the other, but none flows through p.

Let us now suppose that instead of being either directly in step or directly opposed, the pistons are actuated

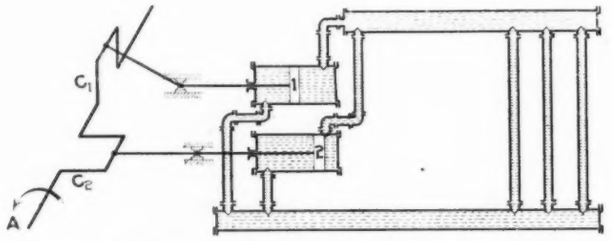


FIG. 7. HYDRAULIC ANALOGY OF TWO ALTERNATORS CONNECTED IN PARALLEL, 90 DEG. OUT OF PHASE

from cranks placed at right angles to each other, as, for example, in Fig. 7. If the crankshaft is being driven in the direction of the arrow A, both pistons will be moving from right to left from the position shown until the crankshaft has been turned through 90 deg. Piston 1 will then be at the end of its stroke and will begin to move from left to right, whereas piston 2 will be at about the middle of its stroke and will continue to move from right to left. The result is that during a complete revolution of the crank the two pistons are moving in the same direction at certain times and in opposite directions at others. Consequently, water will be transferred from one cylinder to the other during parts of a complete forward and return stroke, but at other times all the water will flow through p. The nearer the cranks

ened to the behavior of two alternators in parallel. Thus, in Fig. 8 we have two alternators connected in multiple to a load L. If a_1 and a_2 are both positive, and at the same stage of a cycle—that is, if the alternators are in phase—we would have the condition of Fig. 5 and current would flow from a_1 and a_2 to L and back to b_1 and b_2 during one-half of a cycle and in the reverse direction during the other half. The relation between the voltages would be expressed by the curves in Fig. 9, the two being coincident. When the voltages are directly opposed—that is, when they are 180 deg. out of phase, as illustrated in Fig. 10—the conditions would be those represented in Fig. 6. If they are out of phase

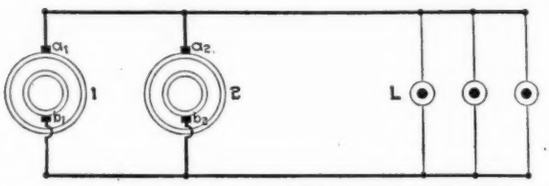


FIG. 8. DIAGRAM OF TWO ALTERNATORS CONNECTED IN PARALLEL

by some other angle, the curves in that case would have some relation, such as that in Fig. 11. If the alternators are running at different frequencies, the curves would be something such as those in Fig. 12, and the phase difference would be continually changing from zero to 180 deg.

From the foregoing it is apparent that to prevent short-circuits between alternators when connected in parallel, they must be connected together when in phase, and that their frequencies must be the same at that time. We therefore have three things to observe when about to connect an alternator in parallel with others, namely, that its voltage is the same as that of the mains, that it is in phase with the main voltage, and that it is running at the same frequency as the rest of the systems. Once

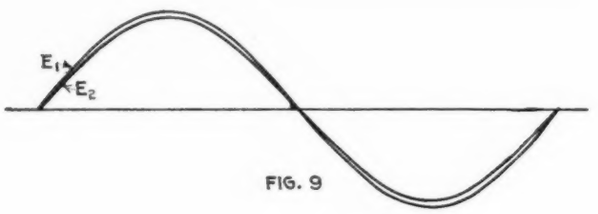


FIG. 9

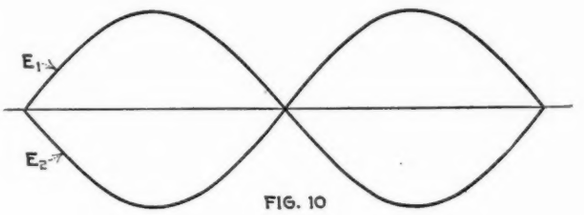


FIG. 10

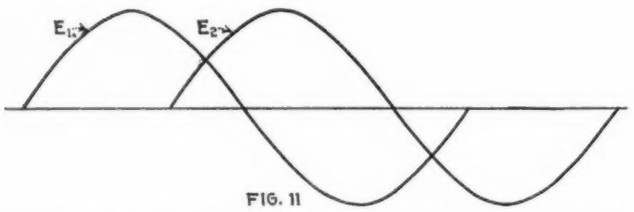


FIG. 11

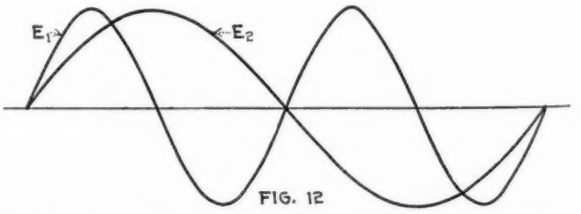


FIG. 12

FIGS. 9 TO 12. CURVES REPRESENTING DIFFERENT RELATIONS BETWEEN TWO ALTERNATING VOLTAGES

c_1 *and* c_2 of Fig. 7 come to being in the same direction, the more nearly will all the water displaced by the pistos pass through p, whereas the nearer they approach direct opposition the more nearly will all the water merely pass from 1 to 2 without causing any flow through p. If the pistons were driven by separate cranks whose speeds were not the same, we should have constant changes in the conditions, ranging from all the water circulated through the pipe system, to where no water circulated in the pipes, but just within the pump only.

The foregoing examples, Figs. 5, 6 and 7, may be lik-

an alternator has been connected to the system, its frequency will be that of the system, under all ordinary conditions. Thus, if its prime mover tended to slow down, the alternator would act as a motor and take power from the other machines to cause the prime mover to maintain its speed. On the other hand, if the prime mover tried to speed up, it would tend to increase the frequency of its alternator, and this it could do only by increasing the frequency of all the other machines connected in parallel with that alternator.

The fact that all the machines on a system run in unison at all times, is the cause for a feature in the

parallel operation of alternators that differs widely from the similar operation of direct-current generators, namely, the manner in which the load on the system is divided among the machines. In direct-current practice the generators are driven by prime movers, such as steam engines and turbines, and water turbines. The prime mover is equipped with a governor which maintains a nearly uniform speed. Not absolutely uniform, however, because it requires a slight drop in speed to cause the governor to act to admit more steam or water. Thus, when it is desired that a direct-current generator shall take a greater proportion of the load on the system, its field flux is increased by cutting resistance out of its field rheostat, thus causing an increase in generated voltage and a corresponding increase in the load current. The increase in load results in a slight slowing down of the prime mover, sufficient to cause the governor to admit the additional steam or water required by the added load. Hence, to increase the load on a direct-current generator, it is only necessary to cut resistance out of its field rheostat.

An attempt to increase the load of an alternator in the same manner would, however, result in failure. The speed of the machine being fixed by the frequency of the system to which it is tied, an increase of field current can only increase the generated voltage, but cannot make the machine slow down, and hence cannot make the governor admit more steam. Consequently, the alternator cannot assume more of the load, and the field-current adjustment does not change the load distribution. It is found, however, that such an increase in generated voltage causes a current to circulate between the generator of higher voltage and those of a lower voltage, thereby causing a greater current to flow through them than that required by the load, and consequently causing an unnecessary loss in the machines. It is therefore a part of correct parallel operation to see to it that all the machines have like excitation.

Since the load cannot be altered by field-current regulation, the question arises, How can it be adjusted? The prime movers of alternators must be equipped with governors that can be adjusted while the machines are in operation. Then, when the load is to be increased, the governor is adjusted slightly, causing it to admit more steam or water, as the case may be. This will tend to cause the machine to increase in speed. However, a very slight increase in speed will serve to make the alternator take a greater share of the load than before, and so reduce the load on the others.

In the last problem it was stated that the line ammeters of a 6600-volt three-phase system read 400 amperes at a power factor of 78 per cent. It was required to determine the total power taken by the system and to find the voltage and current for each leg of the load if connected in delta. The total power is $Kw. = 1.73 \times E \times I \times P.F. \div 1000 = 1.73 \times 6600 \times 400 \times 0.78 \div 1000 = 3562$ kw. In a delta-connected load the voltage across each leg is the same as the line voltage, and in this case, therefore, equal to 6600 volts. The current in each load is equal to the line current divided by 1.73, so that we have, load current $= \frac{400}{1.73} = 231$ amperes.

It was further required to find the same quantities as in the foregoing, when the power factor is 72 per cent. and the load connected star. The power will, as before, be $Kw. = 1.73 \times E \times I \times P.F. \div 1000 = 1.73 \times 6600 \times 400 \times 0.72 \div 1000 = 3288$ kw. In a star-connected load the voltage across each leg is equal to the line voltage divided by 1.73, so that we have, load voltage $= \frac{6600}{1.73} = 3806$ volts. The current per leg is the same as the line current, namely, 400 amperes.

In a balanced three-phase system the wattmeter indicates 150 kw. The load is connected delta, and ammeters and voltmeters connected into each leg indicate 300 amperes and 220 volts, respectively. Find the line current, the load in kilowatt-amperes and the power factor of the system.

Electric Welding of a Diesel Cylinder Head

By L. H. Morrison

An interesting repair was made some time ago on one of two used American Diesel engines purchased by a light and power company. These engines were to be used in the tropics. It is well known by the majority of Diesel operators that this make of engine has a decided tendency toward fracturing the cylinder head at the point *A*, Fig. 1. It is apparent that this bridge is

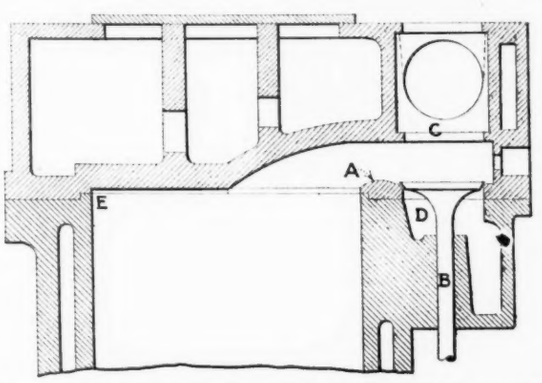


FIG. 1. SECTION OF DIESEL CYLINDER HEAD SHOWING BRIDGE WHERE CRACK OCCURRED

alternately cooled by the air entering through the admission valve *C* and heated by the hot gases blowing out through the exhaust valve *B*. This produces at *A* surface fractures that gradually extend through the entire bridge. As soon as the fracture appears at *D*, the cylinder compression is lost.

The engine referred to had all three cylinder heads fractured at this point. One of the bridges had opened up about $\frac{1}{16}$ in., while the other two merely showed cracks which, though minute, extended entirely through the bridge. It was found advisable to weld these before shipment. Since the joint at *E* employed no gasket, being ground to a fit, electric welding was resorted to in order to avoid danger of distortion of this ground

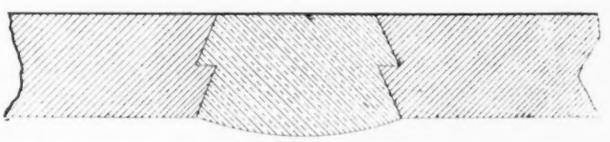


FIG. 2. SECTION OF BRIDGE SHOWING HOW CRACK WAS WIDENED TO FORM KEY FOR NEW METAL

joint, experience having proved that acetylene welding invariably warped the bridge.

In preparing the head for the welding operation, the fracture was widened to about two inches. The groove was made with a key, or offset, in order to lock the added metal in case the weld was not absolutely successful. A cross-section of the break after the new metal was in place is shown at Fig. 2.

In the welding operation, since only alternating cur-

rent was available, a special form of auto-transformer was used, giving about 70 volts at the transformer terminals. This was further reduced to 55 volts at the tip of the welding iron by the resistance of the iron and wiring.

When adding the new metal, the bottom of the cut was filled with molten metal and water sprinkled on it for cooling purposes. The surface of this added metal, since it oxidized rapidly, was cleaned with a wire brush and more metal added. This was continued until the entire cut was filled.

The head as it appeared after the welding operation was finished is shown in Fig. 3, the lighter portion being

FIG. 3. WELDED HEAD BEFORE GRINDING

FIG. 4. WELDED HEAD AFTER GRINDING

the new metal above the surface of the head. This metal, of course, had to be smoothed off so as to make a joint with the cylinder casting. A portable grinder was used in removing most of the excess metal; this was followed by filing and scraping. The new metal had all the appearance of steel rather than of cast iron, and the application of the water had hardened it to such an extent that filing was almost impossible. A view of the head after the grinding and filing was completed is given in Fig. 4. As the illustration shows, the new metal did not actually unite with the iron of the head, the bond was rather a mechanical one and the key, Fig. 2, apparently held the weld. Doubt was felt as to the service to be expected from these welded heads since it was believed that as soon as they warmed up the weld would let go. Fortunately, no such trouble has appeared.

Illinois Forced-Draft Chain-Grate Stoker

The Illinois Stoker Co. has recently placed on the market a forced-draft chain-grate stoker with which rates of combustion as high as 70 lb. of Illinois bituminous coal per square foot of grate surface per hour have been maintained. Air is supplied under pressure, as by the blower *A*, Fig. 1, to a windbox in the side wall. U-shaped tuyere boxes of 12-gage sheet iron extend across the furnace, being bolted at their ends to flanges cast upon the side frame, and at their tops to cross-girders. In the larger installations it is necessary to supply air from both sides of the furnace.

The air is admitted to the tuyere boxes from the windbox through the cast-iron sleeves, which enter the circular flanged openings in the side frame and are removable to permit the withdrawal of the stoker. The admission of air to the tuyere boxes is controlled by means of hinged dampers in these sleeves, or by means of long cast-iron dampers operated through the side wall and located in the tops of the tuyere boxes. These long dampers are attached to spindles which terminate outside the setting wall in handles provided with means of securing them in the fixed position desired. These handles are shown at *D* in Fig 1.

Upon the cross-girders are longitudinal girders on skids which carry the grate. These skids have hardened surfaces and have been adopted instead of rollers for the purpose of maintaining the surface of the grate level and reducing the amount of drippage, also to avoid trouble with rollers becoming fouled.

In some of the stokers at present in operation the skid bars are used only for the top grate, the roller construction being retained at the bottom, as shown at *E* in Fig. 2. In the later types, however, skids for carrying the returning grate are used. These are iron beams, 1 in. thick by 7 in. deep, set on edge in the foundation and extending the full length of the grate.

The grate slides along the tops of the tuyere boxes upon the hardened skids, as shown in the elevation Fig. 2 and upon a larger scale in Fig. 3. The air passes from the tuyere boxes upward through the openings in the grate to the fire.

In forcing air through the grate some means must be provided that will prevent the longitudinal leakage of

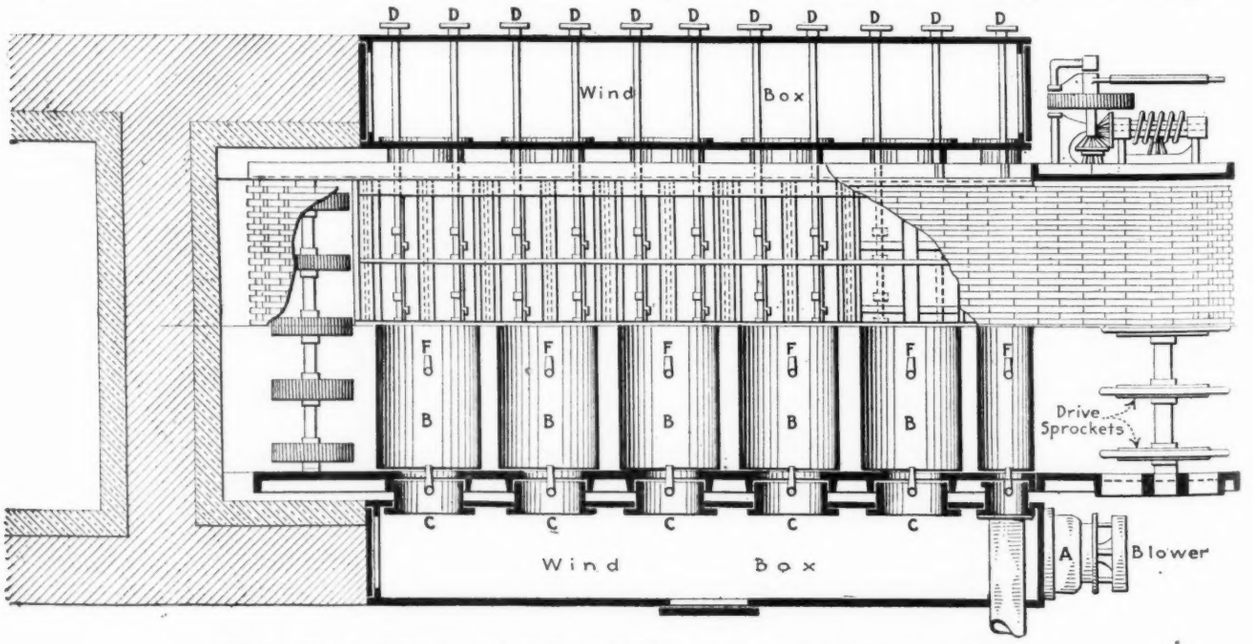


FIG. 1. PLAN VIEW OF ILLINOIS FORCED-DRAFT CHAIN GRATE STOKER

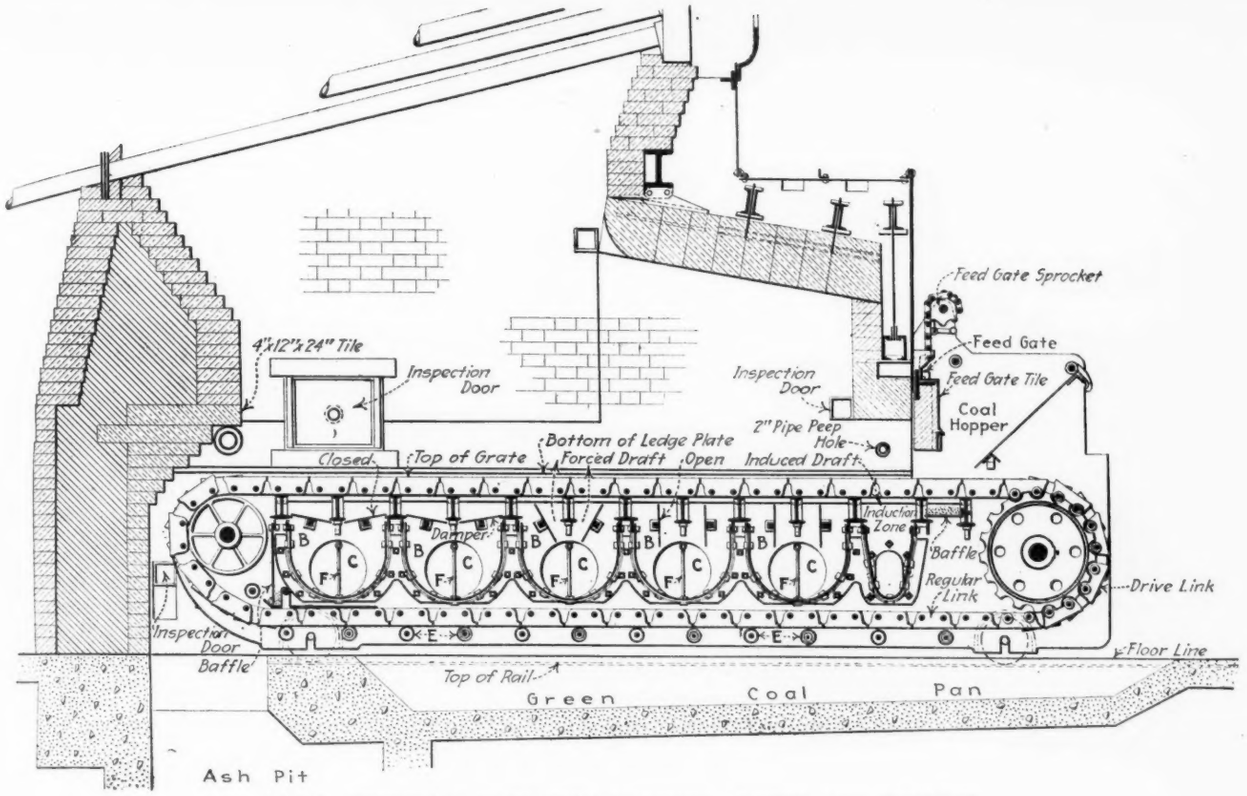


FIG. 2. SECTIONAL ELEVATION THROUGH STOKER AND FURNACE

air along the links. This is accomplished by providing a small, narrow, vertical rib on the link, so located that the air in passing longitudinally along the grate must zigzag around these ribs. The tortuous path thus imposed on the passage of air along the grate reduced leakage due to this cause to a negligible amount. At the top of this rib and parallel to the top of the link is a small apron designed to prevent excessive drippage of fine particles of coal between the ends of the links. This link is designated as the "regular link" and forms the body of the grate. In addition there are three other special links—the drive links, the side or seal links, and the center links. The center links are necessary only in the use of the double-drive stokers. The drive links are designed to permit the insertion of a drive roller between them. The drive rollers engage the teeth of the drive sprockets keyed to the front shaft.

All stokers 10 ft. wide and over are provided with double drives; that is, the grate is composed of two individual chains, each driven separately. There is a decided advantage in this method, inasmuch as the fire can be maintained uniform across the grate by speeding up or slowing down either side as necessity may require. The additional advantage gained by the double drive is the elimination of distortion due to the unavoidable torsional deflection of a long driving shaft.

Siftings are removed from the tuyeres by means of steam or air jet blowers, indicated at *F* in Figs. 1 and 2, which deliver the siftings into the windboxes, out of which they are removed by hand through hinged doors.

The stoker has been adapted to the burning of several classes of fuel by slight changes in the design. The small tuyere in front, shown in Figs. 1 and 2, is not used in stokers designed for burning bituminous coals. It is not a pressure tuyere as are the remaining ones, but is connected to an exhaust fan and is termed the induction zone. Its purpose is to maintain the ignition when burning anthracite and lignites. It has been found that the use of the induction zone for burning anthracite culm is not necessarily continuous, but at times, when for some reason the ignition tends to leave the feed gate, the induction must be used. When burning lignite the drying out of the fuel is materially aided by means of the induction zone.

In a certain installation that has been in service for some time each tuyere or zone is supplied with air by means of a separate turbo-blower. Tests on the installation gave a combined efficiency of 73.3 per cent., which could probably be increased to 76 per cent. by converting the open waterbacks and water-cooled clinker plates into the closed type. At normal rating the boiler is designed for 500 hp., and the records show an average for 24 hours of 1370 hp.

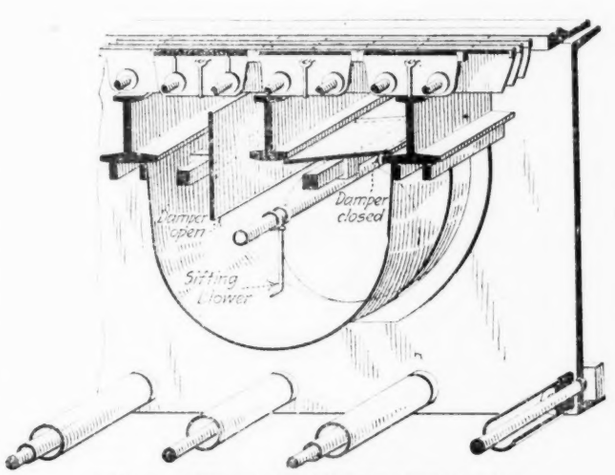


FIG. 3. DETAIL OF ONE BLOWING ZONE

Systematic Study of Boiler Performance

How the Emergency Fleet Corporation Studies Its Water-Tube Boilers for Different Methods of Baffling, Hand and Automatic Stoking, and Oil Firing

THE success of the merchant fleet, the construction of which was undertaken by the Emergency Fleet Corporation, depends in no small degree upon the effectiveness and efficiency of the boilers with which it is equipped. Never before, perhaps, has so large an enterprise been started with so clean a slate and with such an opportunity to evolve the apparatus best adapted to the required service.

A study of boiler types indicated that, under the conditions, the water-tube type led in advantages. The Scotch marine boiler, on account of the impracticability of transporting it by rail intact, could be manufactured only on the seaboard. Heavy plate was difficult to procure because of other demands, and there is about two and a half times as much steel in a Scotch as in a water-tube boiler of the same capacity. The water-tube type could be built by numerous shops all over the country and easily transported to the coast, and its cost was about one-third of that of the Scotch marine.

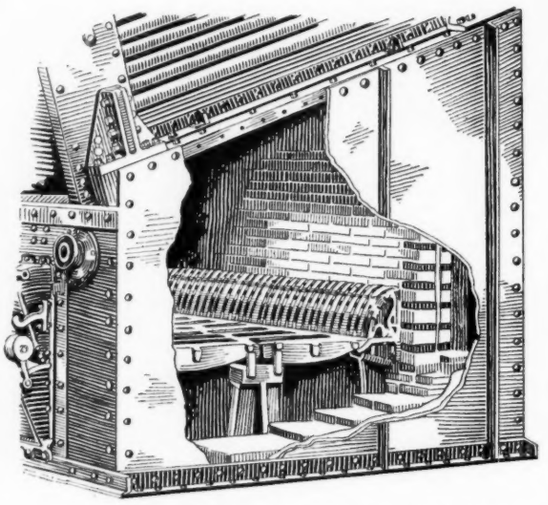


FIG. 1. WAGER BRIDGE-WALL IN MARINE WATER-TUBE BOILER

If the performance of steam boilers had been studied scientifically and only those best adapted to the fuel and conditious used since the boiler became a large factor in industry, an immense amount of fuel would have been saved and the cost of the products of industry would have been correspondingly reduced. The Emergency Fleet Corporation was buying about 1400 boilers of one design and size, all for the same kind and size of ships, and was afforded an opportunity to determine what results were obtainable, and what design, proportions, baffling, accessories and methods of operation would produce the best results.

Among those whose aid was enlisted by the Emergency Fleet Corporation in carrying out its work was the well-known mechanical engineer and boiler expert, F. W. Dean, of Boston, and one of his duties was that of testing the boilers produced. The activity developed into more than the determination of accomplished results by the opportunities which it offered of finding out how those results could be improved.

At the shops of the Erie City Iron Works the writer saw in operation under test conditions one of the Emergency Fleet standard water-tube boilers for wood ships built by the Erie City Iron Works, equipped with every conceivable sort of apparatus for determining what was going on within. The boiler was designed by the Emergency Fleet Corporation; has a cross-drum and water-legs, the latter being fitted with key caps. There are 409 three-inch tubes of 7 ft. 7½ in. exposed length, the total heating surface of the boiler being 2510 ft. It was fitted at the time with two Type E stokers, but had been tested with various types of furnaces. The grate area for hand firing was 77.45 sq. ft., and the pressure carried was 200 lb. The three upper baffles are of plain uncovered seel plate, and the lower one of tile.

For hand-firing, fixed grates and in-swinging counterweighted doors were used, the latter being surrounded by perforated hollow jambs and lintels admitting an un-

FIG. 2. FRONT OF BOILER, SHOWING FIRE DOORS

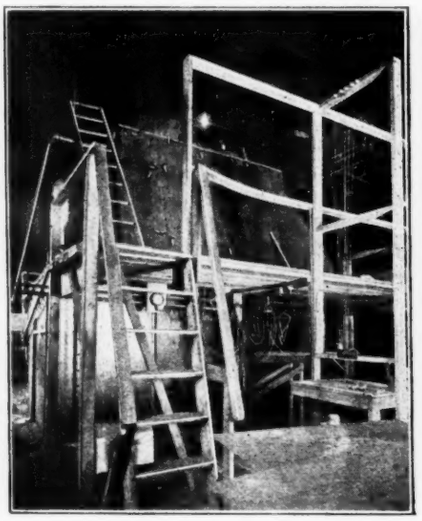


FIG. 3. OBSERVATION PLATFORM AT REAR OF BOILER

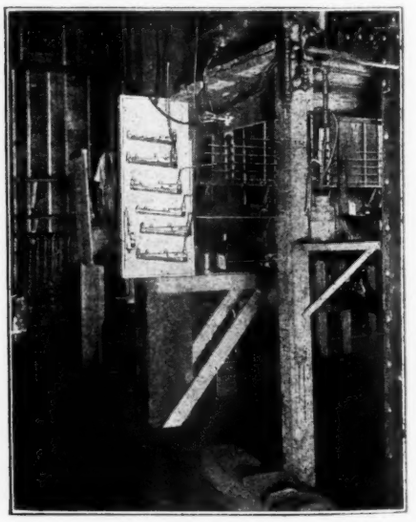


FIG. 4. DRAFT GAGES AND MEASURING INSTRUMENTS

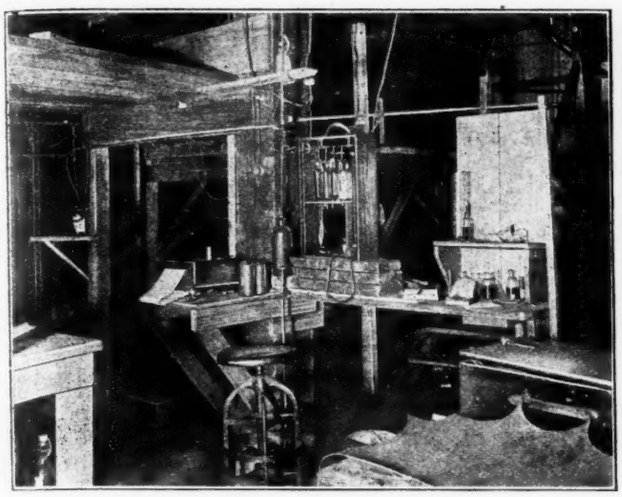


FIG. 5. ORSAT APPARATUS FOR ANALYZING FLUE GAS

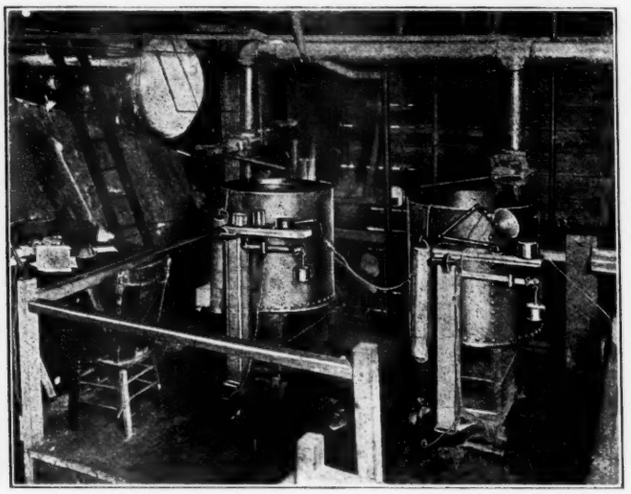


FIG. 6. TANKS AND SCALES FOR WEIGHING FEED WATER

usually large supply of air over the fire. This was supplemented by the use of the Wager bridge-wall, Fig. 1, which admitted air and cleared up a space of triangular cross-section toward the rear of the furnace where the combustion had been faulty. Capacities were obtained with hand firing up to 213 per cent. of land rating, but with the stokers the capacity was carried up to 306 per cent. of land rating, with an efficiency of 71.5 per cent. The best efficiencies obtained were 73.3 per cent. with hand firing and 79.2 per cent. with mechanical stokers, at evaporations of 5.83 and 5.3 lb. per square foot of heating surface respectively from and at 212 deg. The maximum rates of evaporation per square foot of heating surface per hour from and at 212 deg. were 7.4 lb. by hand firing and 10.57 lb. with the stokers, respectively. The boiler was set in a steel casing, and different kinds of refractory and heat-insulating lining materials were tested. Thermocouples indicated the temperature of the firebrick and of the outside of the steel casing, while thermometers showed that of the contiguous air.

Measuring Coal and Air

The coal was weighed on platform scales, and from it 1000 lb. was taken each 24 hours for sampling. There were counters upon the feeding mechanism of the stokers. When the stoker was used, the quantity of air admitted to the furnace was measured by calibrated orifices in a galvanized suction chamber connected to the fan that supplied the air. The gases were sampled at fifteen places in the furnace, three in the first pass and in the center of the uptake.

There was a draft gage between the end of each baffle and the nearest header and a movable exploring tube passing through hollow stay-bolts enabled the velocity and paths of the gases at various points to be determined. This velocity reached at some times and points 50 ft. per sec. Many inert localities were found, notwithstanding which the efficiencies kept up wonderfully.

There was an arrangement whereby a metered quantity of gas could be withdrawn from the furnace and analyzed for tar. Soot blowers were provided, and the conditions under which the boiler was operated furnished an opportunity for observing the effects of its use. With George's Creek Cumberland coal, hand-fired, the temperature of the uptake gases would increase about 35 deg. in two hours after blowing the tubes. With the stoker there was no noticeable rise in the uptake temperature two hours after using the soot blower. A Bailey boiler meter furnished a guide to the firemen.

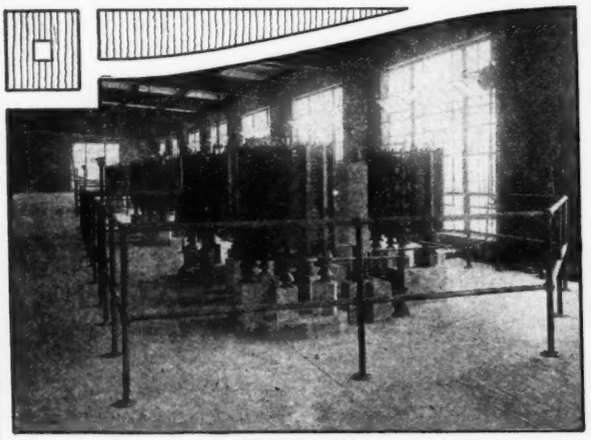
The uptake temperature was taken by five thermocouples, movable across the uptake, the temperature being taken at eight points in the traverse by each couple. A stationary couple at the center of the uptake served as a check.

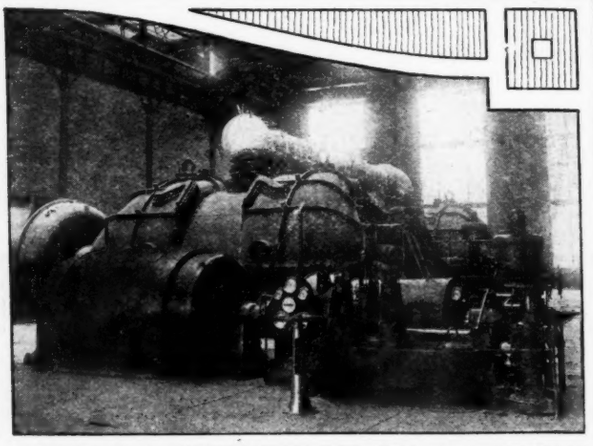
The water was weighed in the tanks shown in Fig. 7 and discharged into a suction tank provided with a hook gage for establishing starting and stopping levels. The feed-water temperature was taken by a thermometer in a well in the feed line near the boiler. The direction of flow and velocity of the water in the boiler tubes was shown by eight propellers on shafts passing through stuffing-boxes in the key caps. These propellers were in a vertical plane, and gave an accurate idea of the circulation. The shafts were almost frictionless, and the number of revolutions was recorded by an electrical apparatus. A pneumacator allowed the water level to be read at the observer's desk or any other desired point or points.

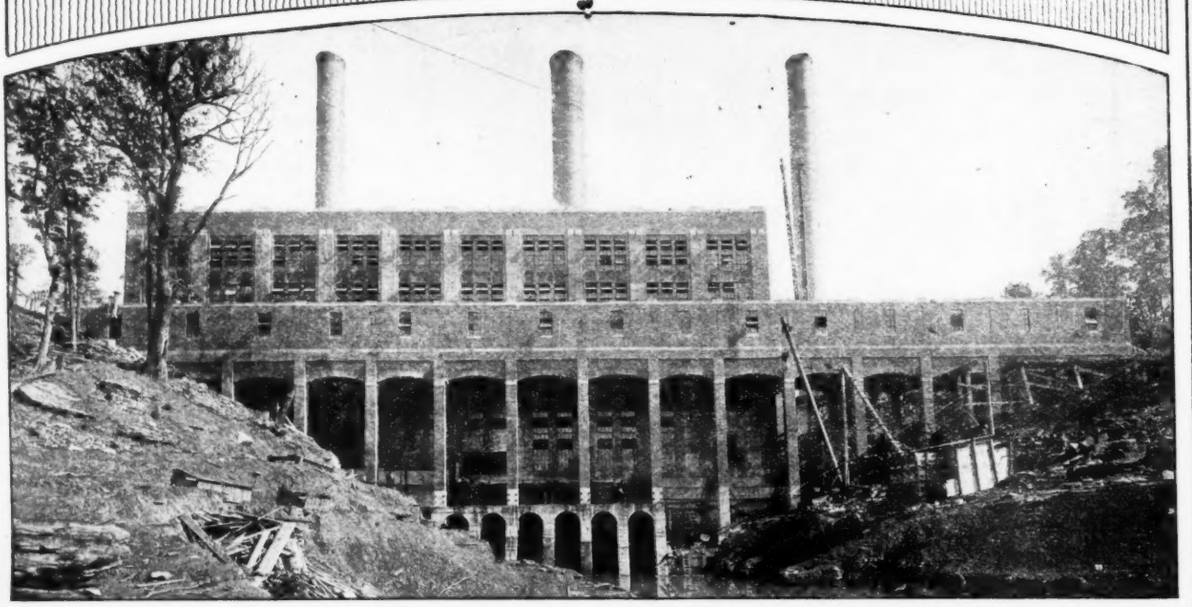
A throttling calorimeter determined the quality of the steam, and a U-tube the loss of pressure through the dry pipe. The exhaust from the stoker engine was condensed and weighed. Draft up to 2⅝ in. could be produced with a steam jet.

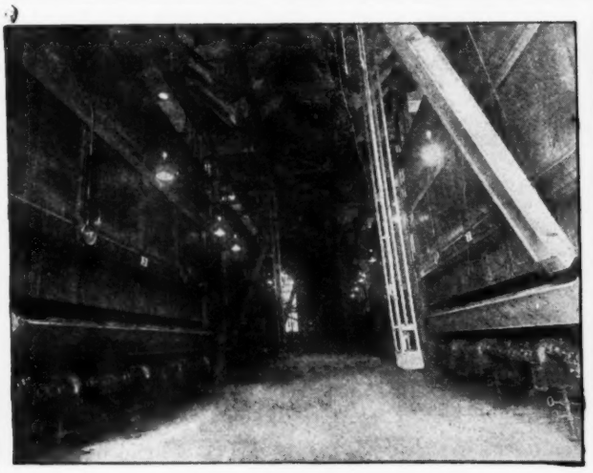
Tests have been made with different methods of baffling, with hand and automatic stoking when burning coal, and with several kinds of oil burners, demonstrating the possibility of maintaining efficiencies of 72 to 79 per cent. It is to be hoped that the results will some day be available to the public.

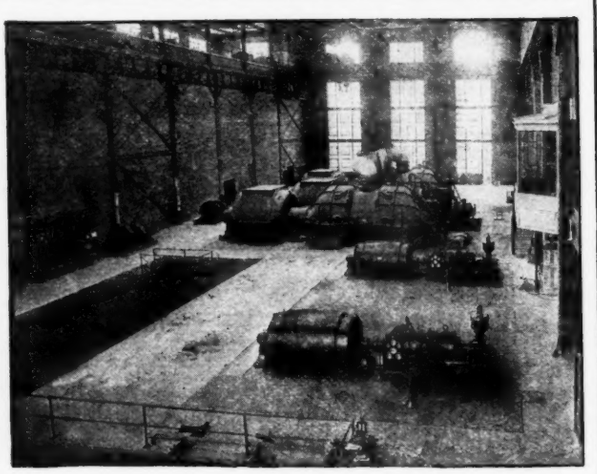
With the regulation of electric utility rates to provide only sufficient return on capital investment to attract new capital to meet the constant demands for expansion and development, and with a courageous attitude on the part of state regulating bodies to see that such reasonable return is allowed to utility companies, the electric industry is free from politics and may devote its entire energies to its duty of adequate and comprehensive service to the public. Broad, honest and courteous service at every point of contact with the public makes for contented and satisfied consumers. We all know that a sound, substantial income, as the result of good service to contented patrons, is much more to be desired than income based on unnecessary consumption of energy and indifference to the real interests of our consumers.—*R. H. Ballard, Pres. National Electric Light Association.*











RECENT VIEWS POWER PLANT, AIR NITRATES NO. 2, MUSCLE SHOALS, ALA. CENTER: VIEW OF THE STATION FROM THE RIVER. UPPER LEFT: REACTANCE GALLERY. THE MAIN 60,000-KW. TURBINE AT THE RIGHT. LOWER LEFT: THE BOILER ROOM. LOWER RIGHT: INTERIOR TURBINE ROOM, TWO 15,000-KW. UNITS IN FOREGROUND

EDITORIALS

An Announcement to Our Readers

THE editor would like to write to each one of you and thank you personally for the gratifying support that you have given us during the attack upon us of the printing unions. Despite the fact that eight issues of *Power* have been delayed on account of this trouble, we have not received one letter reproaching us for this delay from our thirty-four thousand subscribers.

Our advertisers have been equally generous with us. They have told us to go ahead and repeat their copy as often as expedient. The combined coöperation of subscribers and advertisers is of course something that we appreciate highly.

While we cannot say that our troubles are altogether over, we are getting out of the woods and our press room and composing room look almost normal again. Two courses are open to us. One is to catch up as fast as we can with these delayed issues, bringing out an issue, say, every five days until we are again even with the calendar. The other alternative is to double up the editorial section for enough issues to bring the reader up to date by the first of the year.

This latter alternative, it is hardly necessary to say, is vastly more expensive inasmuch as we, by so doing, will omit the equivalent of five complete issues of advertising. We feel, however, that it is a matter of duty on our part to bring the reader up to date with his issues just as soon as possible, and also a duty on our part to pay the cost of this strike out of our own pockets and not pass it along to the advertiser. It is the McGraw-Hill Company's cash contribution toward sane American industrialism.

In this issue, therefore, we are publishing a double editorial section covering the issues of Oct. 28 and Nov. 4, with the advertising section that corresponds to one issue only. We plan to double up in this way until the end of the year and, having caught up with the calendar, hope to greet you as regularly and heartily each week in the future as we have in the past.

Power Plant Wages

The table in this issue showing wages paid in power plants will not only interest operators themselves, but will also be an aid to employes in assisting them to determine whether they are paying above or below the prevailing wage for the size and type of plant concerned.

One point is clearly brought out by this investigation. There is not only great diversity in wages as concerns type and size of plant, but there is also wide variations among similar plants. The pay in many of the smaller plants is ridiculously low, considering the responsibilities carried and the qualifications necessary. This is especially evident when comparison is made with the prevailing wages in many of the trades requiring infinitely less training and skill. On the other hand, the operating men in many of the larger plants are receiving what may be considered fair compensation for their services. In certain sections the union men are found to be better off as concerns both hours and wages, although in other instances non-union plants will be found paying above the union scale. In fact, it will be noted that there is considerable variation in the union scales themselves.

Statistics published recently by the New York State Industrial Commission indicate that the average weekly pay received by employes of water, light and power plants in New York State is at present $28.80, compared with $15.37 for 1914, an increase of 87 per cent. In New York City the figures are slightly higher, being respectively $29.36 and $16.21. While this has just about kept pace with the increased cost of living, it is evident that the figures for 1914 were abominably low.

Size and Capacity of Single-Shaft Steam Turbines

PRESENT limits of the size and capacity of single-shaft steam-turbine-driven units furnished an interesting subject for the recent New York meeting of the American Institute of Electrical Engineers. The turbine designers agreed that the limit of a single-unit turbo-generator does not lie in the generator, but in the steam turbine and in the last wheel of that. The Westinghouse man said that this limitation might be avoided by making the turbine in two or three separate compounded elements, each driving its own generator and each capable of operating alone on high-pressure steam in emergencies. The General Electric man said, in the discussion, that inasmuch as each element had to have its own generator, one might perhaps better avoid the problems of the large-capacity unit by dividing the installation into a number of identical units of smaller capacity than into a number of dissimilar units forming the successive stages of a compound of large capacity.

The electric-generator designer said that, as far as the generator is concerned, with speeds of twelve hundred revolutions per minute and lower the stator, and with higher speeds the rotor, is the limiting member. If operating engineers want units of fifty thousand to one hundred thousand kilowatts, there is no question but that such generators can be conservatively designed and constructed.

Representatives of the General Electric Company explained that several of the accidents that have occurred to large turbines of the single-shaft type were due to fluttering and vibration of the wheels, which had been brought about by making them too thin in an effort to save weight and space. The stresses due to centrifugal force were less than those in wheels made from weaker material that had operated for longer periods of time, but the vibration gave a periodic character to the stresses and gave rise to the formation of fatigue cracks. Stiffening the wheels and putting the openings in them nearer to the hub, where a suitable reinforcement could be provided, had overcome the trouble.

A striking demonstration of the action that was taking place was furnished by experiments with rubber disks at Schenectady. These disks, made to simulate turbine wheels, were rotated at high rates of speed and were illuminated by static sparks discharged by a contact point upon the revolving shaft so that the illumi-

nation came when the disk was in the same position each time, and to an observer it appeared to be standing still. By watching these disks at various speeds, they found out many things that they were looking for and one, at least, that they were not. On one of them that was particularly thin and quite light at the rim, a sinuous distortion appeared and worked around the circle at a speed varying with, but not proportional to, the number of revolutions per minute.

The magnitude and complexity of the problems with which the turbine designer has to deal were brought out in the discussion, and the utter impossibility of the development of apparatus of this sort except by establishments having such resources in brains, money and facilities as those represented in this discussion presented itself. If we had known all about the principles and possibilities of the steam turbine a half-century ago, it is doubtful if we could have progressed much faster than we have done in its development and application. For this not only superior tools and workmanship, but organizations which could carry it through the development stages to a successful issue, were necessary.

American vs. Foreign Practice

THE article in this issue of *Power*, describing the Newport Power Station in Melbourne, suggests some interesting comparisons between American and foreign practice in power-plant design. The plant referred to has a total capacity of sixty thousand kilowatts and this is supplied by six separate ten thousand kilowatt units. Judging from American practice, if the plant had been in this country it would probably have been equipped with two units of thirty thousand kilowatts capacity each, or perhaps three units of twenty thousand kilowatts each.

American engineers have worked more and more toward the larger units with the object of savings in first cost, space requirements and operating costs. On the other hand, from the viewpoint of reliability and flexibility the plan of using a larger number of small units instead of fewer units of larger capacity has much to commend it. From the point of economy of operation a thirty thousand or even sixty thousand kilowatt machine need not be very much better than a ten thousand kilowatt unit, and this advantage may often be wiped out by the necessity of running the large unit below capacity a good port of the time. From the point of reliability a breakdown of one machine in a plant having six is obviously much less serious than a breakdown of one unit where there are only two or three.

Another point differing from American practice is the use of two separate casings for the high- and low-pressure cylinders of the turbine in ten thousand kilowatt units. American engineers would probably have used only one casing for machines of this size. Here, again, the foreign method has certain advantages. The temperature range for a single casting is much reduced when two casings are used. Since it is possible to make the high-pressure cylinder single-flow while using the double-flow type for the low-pressure cylinder, the range of blade lengths is much reduced. Both these result in lower stresses in the various parts affected and therefore in simpler design.

We do not want to condemn the use of large units or of the single cylinder, but simply call attention to a plant which illustrates a departure from American practice and to the fact that there are sometimes very good reasons for such a departure.

Fuel Oil and Excess Air

THE instability, or apparent instability, of the coal market along the Atlantic Seaboard is causing many plants to change from coal to oil. Nearly all the plants that have made the change and those that will make it have stacks designed for coal burning. It is well known that it requires more air to burn a pound of oil than to consume a pound of coal. On the other hand, it is not so generally known that losses due to excess air invariably are very much greater than when burning coal, until the crew has become accustomed to oil burning.

A word of caution therefore is not amiss.

The back damper should always be open enough to allow the gas in the furnace to escape if the burner snuffs out and there is no flame to consume the gases. Otherwise there is likely to be a serious explosion. The draft regulation should be by adjustment of the ashpit door or its equivalent. Unless care is used in the regulation of the air of combustion, the many plants now beginning to use fuel oil will be responsible for considerable losses.

The boiler and breeching or uptake from each boiler should be provided with peepholes. Beginners usually get the impression that a white fire is an economical fire. Usually, it is not. White indicates excess air, gray and black too little, and yellowish white and orange just right.

T-Wharf Refrigerating Plant

THE last few years have been active ones in the refrigerating industry, particularly in the development of the high-speed ammonia compressor. Several interesting plants using high-speed machines have been built. Of these surely none is of greater interest than the new T-wharf plant of the Quincy Market Cold Storage and Warehouse Company. This plant is electrically driven by purchased current.

No need here to go into details; the article describes those. The occasion for some comment is that here is a plant so designed and equipped that advantage should be taken to make many tests to determine what plants of this new design can be made to do. Connections are such that condensers and coolers may be operated in any desired manner of water and ammonia gas flow. Thermometer wells abound so that all test temperatures may be had. The plant is in Boston, and it would be worth while indeed, when fully ready, to let the students of the Massachusetts Institute of Technology, under the direction of Professor Edward F. Miller, test the plant for various purposes.

Power Plant Record Forms

THROUGHOUT the year we have many calls for power-plant record forms, daily report sheets, etc. We do not have these. The forms that are successful in one plant are not usually applicable to another. We publish in the course of a year, various record and report forms as used in specific plants. It is from a study of these and others which one may find available that one may draw up forms suitable to one's own plant.

The weakness of most forms is that they are too elaborate. The initial forms which the engineer gets out after considerable effort and time spent, usually call for so many entries that they actually overwhelm the men, annoy them and eventually are ignored. Where one finds a plant using the same forms for years one will learn, upon inquiry, that those in use are the result of many, many rejections and revisions.

CORRESPONDENCE

Unequal Air Gaps Cause Complex Exciter Problems

A peculiar case of trouble occurred in a new station, in which two exciters of identical design and manufacture refused to operate in parallel with any degree of success. The exciters were compound-wound and controlled by a Tirrill regulator. When using a Tirrill voltage regulator on exciters operating in parallel, it is necessary that the voltage regulation of the individual exciters be the same if equal division of the load is to be obtained between them. Proper load division between the machines is usually obtained by adjusting the compounding of the units.

In the present instance voltage-load curves had been taken and adjustments made, yet no adjustment permitted the two exciters to share a changing load equally. Equality of load could be obtained at any time, but if the load changed, one machine would pick up the increase in load while the other would carry only its previous load, or even in some instances lose a portion of that.

A resistance was then inserted in series with the series winding of the machine that took more than its share of the load, this resistance being connected inside the shunt connection. The effect of this was, of course, to cut down the current passing through the series winding of the machine, hence its compounding, and a readjustment of the auxiliary rheostat became necessary. But even so, this machine still picked up any load increase at a much more rapid rate than did the other machine. A further reduction of the compounding was without result.

A readjustment of the settings of the brushes of both machines was made, but while improving matters somewhat, had a very slight affect on parallel operation. In fact, the machine that has previously refused to pick up any load increase began to pick up about 10 per cent. increase as compared to a 90 per cent. increase taken by the other machine. About this time a saturation curve of the sluggish machine was taken. The curve showed that the terminal voltage answered very slowly to the current increase or variation in the field, and this held true at all points of the saturation curve. This curve immediately suggested that there was something wrong with the magnetic circuit of this machine, and an examination soon brought to light the real cause of all the trouble. The air gap was considerably greater than that of the more sensitive machine. Shims, or liners, were procured and inserted between the polepieces and the yoke so as to reduce the air gap between the polepieces and the armature. After repairs a few adjustments of the compounding enabled the two machines to be operated in parallel by the functioning of the Tirrill regulator.

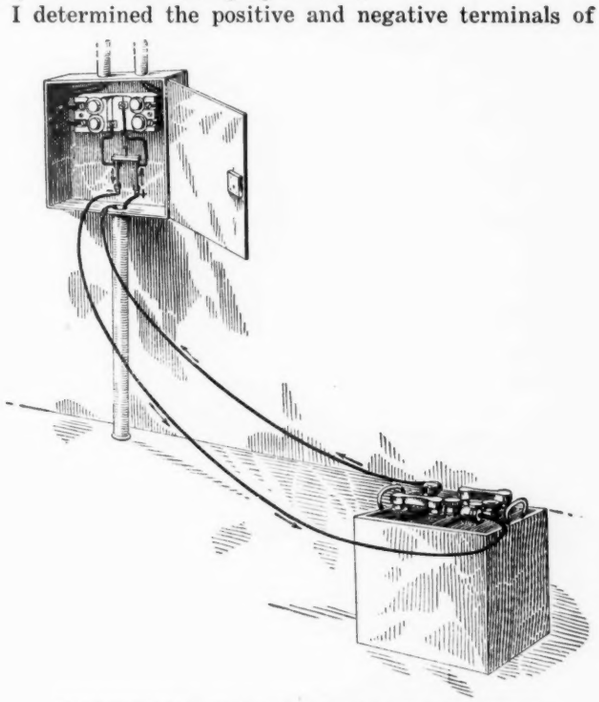
B. W. SMITH.

Cicero, Ill.

Charging Batteries from Lighting Load

The problem of recharging an automobile starting and lighting battery was put up to me recently, with the request to do it without any unnecessary expense. In our machine shop we have twenty 16-cp. incandescent lamps operating on 110-volt direct current. This load is equal to about 10 amperes and seemed to be the most convenient resistance to connect in series with the battery to limit the charging current.

I determined the positive and negative terminals of



CONNECTIONS FOR CHARGING THE BATTERY

the lighting switch and disconnected the negative wire, connecting this to the negative terminal of the battery and the positive of the battery to the switch, as indicated in the illustration. This allowed me to charge the battery and still have enough light in the shop without making up a charging rheostat.

Newark, N. J. ALFRED MESLAR.

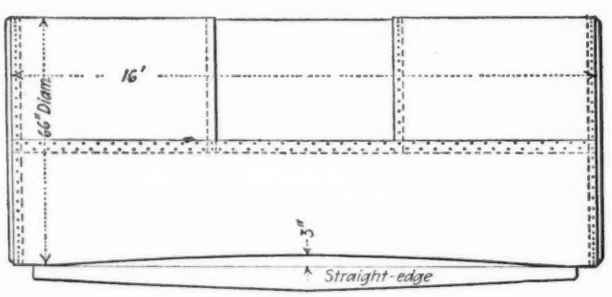
The Length of Boiler Seams

Having had the opportunity as a boiler inspector to see quite a number of boilers with what is known as continuous seams at the longitudinal joints, the invitation on page 191 of the July 29 issue attracted my attention, and my observations may be of interest to the readers of *Power*.

The bottom halves of these boiler shells were constructed of single plates, with the tops in most cases made up in three courses. All these boilers had been in service for quite a number of years, and almost invariably the bottom half, which was made up of a single sheet, was found to be warped in the manner indicated by the sketch. In applying a straight-edge to the bottom of one of these boilers, which was 16 ft. in length by 66 in. in diameter, it was found to be three inches out of line. It is not probable that so much distortion could take place without producing severe and very unequal strains upon the longitudinal seams, whether of lap-riveted or butt-strap construction.

In the case of a boiler made up of two or more courses, one plate to a course, this kind of distortion is hardly ever perceptible, probably on account of the stiffening effect of the circumferential seams.

The butt-strap joint could withstand greater stress than the lap joint, but by breaking up the longitudinal



DISTORTION OF BOILER SHELL WITH LONG SEAM

joint with two or more courses, the safety of the boiler is increased, and the length of butt-strap joints as well as lap joints should be limited in the case of externally fired boilers.

In horizontal water-tube boilers I believe that the drums should be constructed of more than one course on account of stresses introduced by attaching the tubes and water-legs to the drums, for if the utmost care is not exercised when erecting, a full bearing is not maintained at all four corners, and the tubes and drums are subjected to a twisting strain. The tubes, being light, quickly adjust themselves to meet the condition, but the drums are left to withstand these strains.

I have often found, in boilers of the horizontal water-tube type, throat and girth seams that persisted in leaking in spite of being calked several times. As these boilers were entirely free from scale or other harmful deposits, no other reason could be found for this leakage except the twisting strains along with expansion and contraction. When such stresses are resisted by the longitudinal seams, the safety of the boiler is decreased that much, and I believe this is argument enough to limit the length of the longitudinal seams on this type of boiler.

Water-tube boilers of the Stirling type are usually suspended in such a way as to make the drums quite independent of one another, and their connections being so flexible as to permit the drums to adjust themselves to varying conditions, these boilers are not subjected to so many different strains as other types, and it is not so essential to limit the length of their longitudinal seams.

P. E. TERROY.

Chattanooga, Tenn.

Refrigerating Effect of Natural and Artificial Ice

Is there any more refrigeration in a pound of ice that is frozen by nature on a pond, lake or river, than there is in a pound of ice frozen by artificial methods in an ice plant?

I have had considerable experience working in ice plants and have noticed that the artificial ice melts faster and that if a piece of it is put in the mouth it can be kept there without any discomfort, while if the same thing is done with a piece of natural ice it immediately chills the tongue and has to be taken from the mouth. Also, I have observed that ice water made by melting artificial ice can be drunk much more readily than ice water made from natural ice. An engineer friend of mine claims that ice is ice no matter what the conditions are under which it is frozen. I have also noticed that when I have frozen can ice in three or four hours with the brine down to 0 deg. F., it has not the refrigerating effect of the clear ice frozen over a longer period with 20 deg. brine. This may be due to the large amount of air trapped in the ice that is frozen quickly, which would have the effect of cutting down the weight per can.

JAMES S. MACDONNELL.

Rutland, Mass.

["Pigs is pigs," and so ice is ice. But this question is one often in the minds of engineers, and housewives swear that artificial ice melts faster than natural ice. And this is quite possible. However, of two pieces of ice, one natural and one artificial, of equal volume and equal weight and both at the same temperature, the refrigerating effect of one will be no greater or less than that of the other. Perhaps some readers will not agree; however, good discussion of the subject will be published if sent to us.—Editor.]

Engine Running Twenty Years

I have a 68-hp. Corliss engine running over at 80 r.p.m. This engine I believe has been running twenty years and runs with a three-quarter load all of the time.

The bottom shoe has been babbitted once; the piston-rod is packed once a year. If the packing shows leaking steam after six months' use we remove two rings of packing and replace them with new ones. In this way the packing lasts six months longer. There are five rings altogether. Valve rods are packed every two years. Two liners have been put in on the crosshead brasses and two on the crankpin brasses, also two sets of catch blocks have been replaced. One set of leathers were put on bottom of the dashpots and one set of springs on the exhaust valves.

A pressure of 80 lb. of steam is carried on the boilers. We never let the lubricator run empty, and use one quart of oil each day of ten hours. I have no intention of overhauling the engine as it does not need it.

New York City. PATRICK MOLLOY.

Averaging Pressure Charts

The accompanying pressure-gage charts are presented in order to show how the average pressure may be arrived at by means of a planimeter. I have never seen this idea published, but for all that it may not be new.

Take, for instance, the chart shown in Fig. 1. The irregular pen line makes it difficult to determine what the average pressure is. By using my method, the average is easily obtained. The process is as follows: Run a planimeter over the entire irregular pen line. This will give an area of 9.3 sq.in., which is the area of a circle 3.44 in. diameter. Striking a circle on the chart 3.44 in. diameter, as shown, it will give an average pressure of 57 lb.

The same idea is worked out in obtaining the average pressure when the curve is less than a complete cycle of 24 hours. First project the hour lines to the center of the chart as shown in Fig. 2. Then run a planimeter over the pressure line and the hour lines *AB* and *AC;* the area will be 2.10 square inches. From 8 a.m. to 12 noon is 4 hours, or $\frac{1}{6}$ of 24 hours. Then $2.10 \times 6 = 12.6$ sq.in., the area of a circle of the same diameter, or the segment of a circle shown by the pen line, a circle to contain 12.6 sq.in., would be just 4 in. in diameter. Then drawing a 4-in. circle on the chart will indicate 80 lb. to be the average pressure during the 4-hour period.

W. V. WHITE.

Hamilton, Ohio.

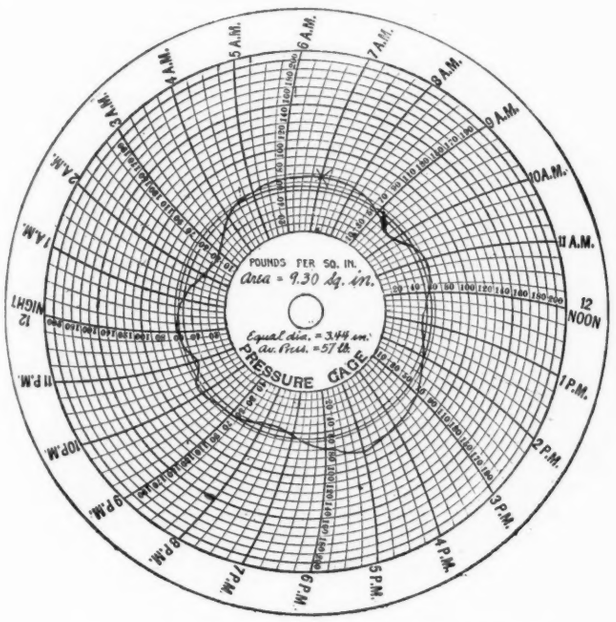


FIG. 1. COMPUTED AREA OF AN IRREGULAR 24-HOUR CHART

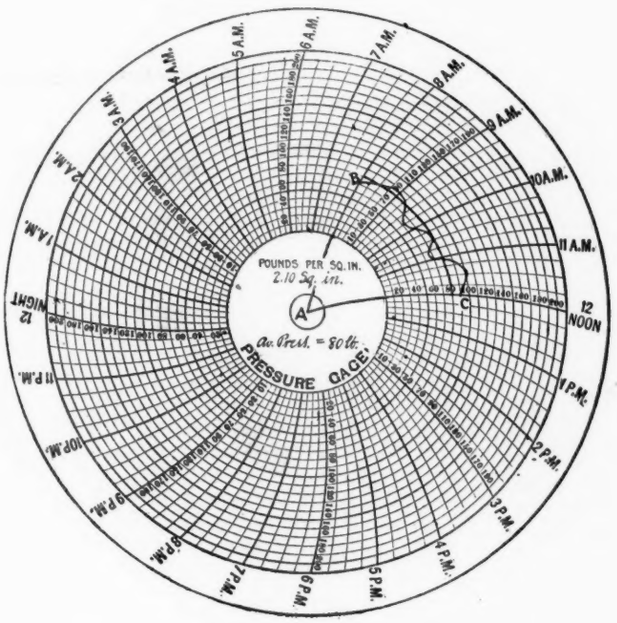


FIG. 2. COMPUTED AREA OF AN IRREGULAR 4 HOUR CHART

Decreased Frequency Caused Rotary Converter to Flash

The alternating-current characteristics of a synchronous converter are similar to those of a synchronous motor. When a rotary converter is driven from the alternating-current end, its speed will vary as the frequency of the circuit. This is also true of the synchronous motor, and the speed at all times is equal to 60 times the frequency divided by the number of pairs of poles. If the load becomes so heavy that the machine cannot run at synchronous speed, it will stop. Where the commutator end of a converter is operated in parallel with the commutator end of other converters, the machine is liable to be operated as a continuous-current motor, at a speed very likely to injure the rotor unless there is provided protective devices to prevent such a condition arising.

A synchronous converter was complained of on account of general sparking and a tendency to flash over between brush-holders or between a brush-holder and the frame of the machine. The shifting forward of the brushes one bar remedied the general sparking; this improvement in commutation decreased the frequency of the flashovers, but did not eliminate them entirely. The high-tension station from which the converter was supplied, was connected in parallel with a similar station, the two supplying the total load of the system.

Occasionally, the oil switches of one station would open and throw the whole load onto the other plant, which was located not far from the converter. The effect of suddenly imposing this abnormal load upon one station was to cause the prime movers to slow down, thereby decreasing the frequency of the current supplied to the converter. On account of the inertia of the converter's armature, its speed could not immediately respond to the sudden change of the frequency; therefore the difference between the value of the speed at which the rotor actually turned and its synchronous speed, could the rotor have instantly responded to the change in frequency, caused the machine to return energy to the supply circuit. The effect of this reversing of the functions of the machine was to so distort the flux distribution in the air gap as to place into a strong field the armature coils that were under commutation, causing severe sparking at the brush and flashovers.

E. C. PARHAM.

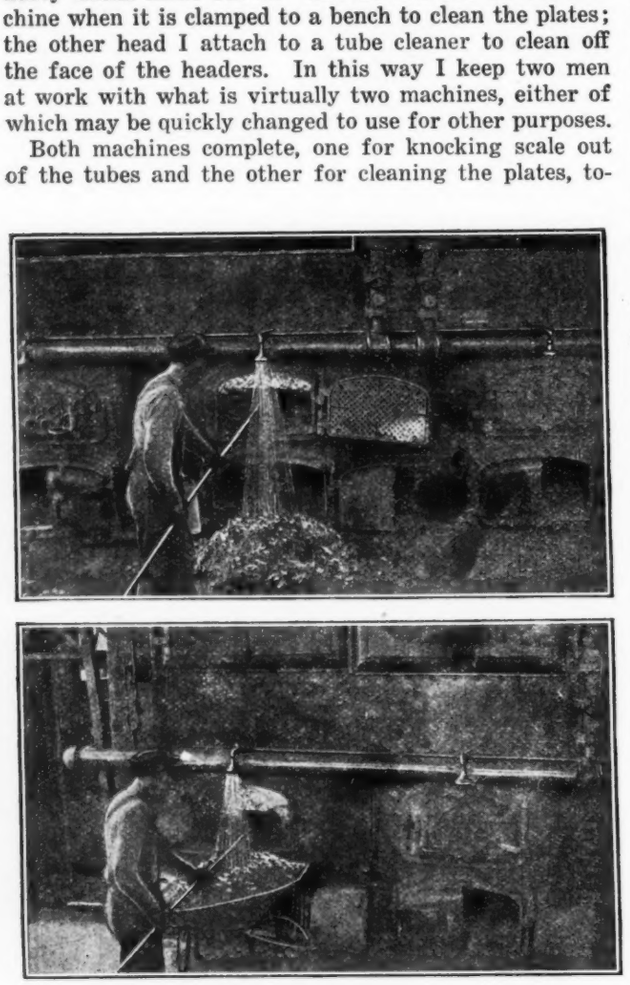
Brooklyn, N. Y.

Cleaning Boiler-Tube Plates

Referring to James M. Purcell's letter relating to cleaning boiler-tube plates, page 397 of the Sept. 2 issue of *Power*, the outfit is quite ingenious.

I have a penumatic machine and I had two extra-heavy heads made for it. One head I use on the machine when it is clamped to a bench to clean the plates; the other head I attach to a tube cleaner to clean off the face of the headers. In this way I keep two men at work with what is virtually two machines, either of which may be quickly changed to use for other purposes.

Both machines complete, one for knocking scale out of the tubes and the other for cleaning the plates, together with the extra heads, cost $110. I have used them three years, and they will stand another year before needing any repairs.



COOLING CLINKERS IN BOILER ROOMS

Ridgewood Manor, N. J. ALLAN A. BLANCHARD.

Handling Superheaters on Locomotive

I have had more experience with superheaters used in locomotive service than in stationary servie, but the same information can be well used in both cases.

In operating superheaters care should be taken not to flood the boiler with water for when the throttle is opened a certain percentage of this excess of water would be suddenly admitted into the dry pipe, superheater header, superheater units, etc., hence the sudden expansion of this water or highly saturated steam coming in sudden contact with the heated metal surfaces of superheater structure would cause more or less destruction to the superheater, by fracturing the joints of superheater units at the connection of the tubes to the cast-steel return bends, at the ends nearest the fire, and the possible loosening of the joints at the connection with the header, etc.

With locomotives in the shop with the fire out, and being hurriedly fired up, care should be taken to see that the superheater does not become flooded with the water getting too high from expansion, as this flooding would cause the water in the superheater to be rapidly gen erated into steam and probably cause the engine to start in case the reversing bar has not been left in the center.

In starting the locomotive care should be taken not to slip the wheels, for if the boiler is very full of water, such a rush of saturated steam through the dry pipe into the superheater will frequently cause accident to some part of superheater structure.

Tying or propping the superheater damper open should be avoided, unless it is impossible to get the engine over the road, especially when the locomotive is drifting and the blower is in operation. Even though the throttle valve is steam tight, the opening of the drifting valve may have been neglected, which would cause the threads on the superheater tubes, or inside the return bends at the ends nearest the fire to be burned. In the case where a locomotive is failing for steam, the boiler may have been filled with water preparatory to making the next grade, and when the throttle is again opened highly saturated steam is suddenly admitted into the superheater structure, which has previously been subjected to unduly high temperatures, caused by the gases of combustion passing through the flues containing the superheater units, which had neither steam nor water in them for protection against the intense heat while the damper was properly used.

Such a condition will cause serious destruction of some part of the superheater structure, and the same results will also exist when a locomotive is fired up too rapidly and the damper propped open for draft.

Steam failures are rarely attributed to defective superheater systems. Steam failures, however, may be caused directly in some cases by one defect or more frequently by a combination of defects, as follows:

Steam failures may be due to fuel containing high percentages of silica, sulphur, iron, magnesium, etc., in combination, and when subjected to high furnace temperature a slag is formed over the grate surface thereby reducing the supply of excess air necessary to complete combustion, hence a lessening of the furnace temperature and a relative drop in evaporation and steam pressure.

Defective drafting of the smoke box; poorly fitted fronts and doors, clean-out caps, loose rivets or bolts in the smoke box also tend to reduce the efficiency of the locomotive and destroy the superheater header. Defective steam pipes, exhaust tip, misaligned stack, etc., tend toward steam failures.

Leaky flues, honey-combed flue heads, flues stopped up with furnace slag, broken-down arches, valves out of square, leaky packing, bad handling of injector and poor firing tend toward steam failures.

Superheaters if treated with ordinary care and common sense are a paying investment in stationary as well as locomotive service, and can be operated in each service successfully and without danger of explosion or failure if simple rules are carried out.

Hagerstown, Md. PAUL R. DUFFEY.

Corrosion Caused by Coal-Pile Seepage

The drainage from coal piles due to the seepage of water through them is not free from dangers, as the water is, or may be corrosive. That the drainage from large coal piles in proximity to power plants must be reckoned with as a possible source of trouble is exemplified by a case of corrosion that occurred in the last fall.

Middle West company was storing about 35,000 tons of Illinois and Indiana screenings near the power house. The pile was about 18 ft. high, and covered considerable ground area. A duct line of lead-covered, paper-insulated high-potential conductors ran alongside the coal pile from the power house to substations. The coal was stored during the summer, and in the fall the heavy rains came while the weather remained warm. Shortly after the downpour of rain one of the underground cables broke down, due to dielectric failure at the manhole nearest the pile. The cable breakdown was repeated—in fact, several cables went down, all in the same manhole, which was in closest proximity to the coal pile.

Poor workmanship and dielectric strains due to test voltages are frequently the cause of the same cable breaking down repeatedly. In this instance, however, it was a different cable in each case. An investigation was started to discover a cause, if possible.

The manhole where the trouble occurred had been found full of water on the first two instances where the cable splicers had made repairs, the water level being up to the height of the cables. Samples of the water, when analyzed, showed the presence of brine, also sulphates of magnesium and iron. A strong odor of sewage and illuminating gas—common occurrences in manholes—was also noticed. The cables were supported on iron pipe embedded in the manhole walls, and a section of this pipe was also submitted to a chemist for analysis together with a section of the lead sheath of a defective cable, the section chosen embracing the splice where the cable had failed.

The cable sheath was badly corroded externally in proximity to the rupture when the cable broke down. The corrosion was not like that due to electrolysis—that is, pitted here and there—but occurred in extensive patches as if due to the water in the manholes. Moreover, it was observed that the patches along the lead seemed to correspond to a possible water level, since they appeared to occur with a fairly straight demarkation. The iron-pipe cable supports showed deposits of oxide of iron, also sulphates and sulphides of iron. The cable sleeve at the splice tested up to quantities of tin and lead sulphide with a trace of iron.

The chemist's explanation of the cable breakdowns was this: The sulphates in the manhole water came from the coal pile. Seepage from an adjacent broken sewer was responsible for the brine in the water. The sulphates aided corrosion, due to local decomposition of the salts with the free acids or brine. The weak spots in the cable splices were soon found and attacked until water entered, ultimately causing the breakdown.

The remedy suggested was either to keep the manhole free of water or to protect the cable sheaths from attack by some form of protective covering. That the manhole should be flooded after coal was stored, although it had been dry before, is probably explained by the fact that the coal pile held the water from the heavy rains, whereas it would otherwise have drained off. The coal pile acted as the equivalent of additional ground surface, and this difficulty could be solved by installing a drainage system. The cable sheaths could be easily protected by covering them with a wrapping of tape or some such binder and coating thoroughly with a suitable paint impervious to moisture and acids. The limitations of this latter practice are, of course, inability to protect the cable inside the duct ends adjacent to the manhole, and to know to what extent the covering actually covers.

The lesson of this incident seems to be that the corrosive possibilities of coal piles should be borne in mind. The seepage, if taken into boilers or condensers, might work havoc in a short time. All apparatus such as water and gas pipes, electric cables and other apparatus should be kept away from the coal pile when possible.

Chicago, Ill. R. H. JACKSON.

Use of Bichromate Salts as Boiler Compound

The writer of this has been interested in the use of certain salts of chromic acid as a preventive of rusting and pitting in steam boilers. Scientific researches have shown that as long as iron remains in contact with bichromate of soda or potash even in dilute solution, rusting does not take place. The assumption is that chromic acid and its salts exercise a polarizing or dampening effect, thus preventing the solution of the iron.

It would be of interest to know whether this dampening action will hold true under high temperatures and pressures. If it will, chromic-acid salts could be used for boiler-treatment purposes where pitting or corrosion is present. Such treatment would be especially desirable where lime or soda is objectionable on account of its tendency to cause foaming in the boilers.

A few years ago the writer was engaged in tests on boiler compounds in locomotive boilers that suffered badly from pitting of flues and fireboxes. After several compounds were tried without success, it was decided to run a test with bichromate of soda. Unfortunately, conditions at that time rendered it impossible to keep the same locomotive under treatment for a period long enough to allow a reliable opinion to be formed. It can be said, however, that the water coming from the boilers when they were washed out did not have as red an appearance as before. This would indicate that corrosion was still going on, although with less intensity than without the treatment. Whether this was due to an inherent inability of the bichromate of soda to overcome or counteract corrosion altogether or merely to the manner and method in which the treatment was carried on, it is hard to decide. It may also be that positive results could be obtained only if the treatment is started in a new or perfectly clean boiler, with its interior surfaces thoroughly soaked with bichromate salts before being exposed to the corrosive action of the water.

Perhaps there are readers of *Power* who have tried these salts against corrosions in boilers and who have gathered some experience along these lines. As many plants are confronted with problems of pitting, it would be of general interest if more light could be thrown on the action of bichromates as preventives of corrosion in steam boilers. H. BLEIBTREN.

Philadelphia, Penn.

Meyeringh Proportional Lubricator

The descripton of the Meyeringh proportional lubricator, on page 95 of the July 15 issue of *Power*, interests me. I understand the principle involved and the object sought, and I presume that it works out all right in practice when correctly applied. Also, I can see where it may advantageously be used in pump operation, but I do not see that it is at all needed in engine operation.

I am of the opinion that the greater the volume of steam per stroke used by any given engine, as the result of increased load upon the engine, the less the quantity of oil required. A fully loaded engine using large volumes of steam per stroke is easy to lubricate as compared with underloaded engines, with an accompanying early cutoff and small steam volumes. As a general thing most engineers think that as the load is increased on an engine more internal lubrication must be supplied, but, all else being equal, the reverse is true. Therefore, it seems to me that the proportional lubricator would not really be needed for engines in which increase of load means increase of boiler steam volume per stroke.

Different operating conditions call for a particular lubricant for each individual case. If an engine is running constantly underloaded, that condition requires a certain kind of cylinder oil. If the load on that same engine is increased, so that the increase is constant, then a different kind of oil should be used if the best results are to be obtained all around. It seems to me that it would not be a case of increase of feed. That alone certainly would not meet all requirements. In an automatic engine the same surface also must be lubricated for any and all loads, for any unit period of time. But the kind of oil to use depends upon the following factors: Load, size, speed, pressure of steam and quality of steam as to whether it is wet, dry or superheated. Sometimes changing one of these factors may affect all the others, with the result that a different kind of oil should be used. If the right kind of an oil is in use, in any given engine running constantly lightly loaded, and the load is considerably increased and the increase is to be constant, then the remedy is not an increase in oil feed, but a change of oil to suit the new conditions that will prevail. Increasing the feed of the same oil used for light-load condition may perhaps do, but not so well as a grade of oil particularly suited to the conditions.

Again, if the wrong kind of oil is in use for the light-load condition, and yet suitable for the heavy-load condition, then increasing the load would not require an increased feed, for it would be likely that in order to secure proper lubrication under the light load with the wrong oil, a superabundance of oil must be used, and less of it will be required when the load condition changes to suit the oil that had been incorrectly used at first.

With proper atomization of the oil before it enters the cylinder, and with the proper kind of an oil to suit the conditions, the least quantity of oil may be used with the best results. Under heavy load conditions a greater volume of steam per stroke is used, greater volume means increased steam-flow velocity, and greater steam-flow velocity means a better atomization of oil than in the case of a light-load condition. With a full load less oil may be used than in the case of a light load, because the oil will be the better distributed and carried to all internal parts.

In the case of a steam pump that may speed up, then, an increase of lubricant is permissible, and so the proportional lubricator has a field in that direction. However, I am not undertaking to unduly criticize the lubricator in question, but simply advancing an opinion, and stand ready to be corrected if I am wrong.

Brooklyn, N. Y. CHARLES J. MASON.

Importance of Efficiency Tests

The importance of efficiency tests upon mechanical equipment cannot be too strongly impressed upon purchasers of such material, as witnessed by the following experience:

I called on one of the large Eastern pump manufacturers to make a three-hour operating test upon a 6-in. three-stage centrifugal pump, direct-connected to a 120-hp. gasoline engine. This pump was to deliver (according to specifications in my possession) 1000 gal. per min. at 1200 r.p.m. and at 230-ft. head.

The gasoline used to drive the engine was placed in a vertical tank, 12 in. in diameter and 4 ft. high. The height of the fuel was measured at the start of the run and the readings were made at the end of each hour and subtracted from the previous height. This gave the amount of fuel consumed. The amount of fuel consumed was then calculated as follows:

$$\frac{h \text{ (in inches)} \times 6 \times 6 \times 3.1416}{231} \text{ gallons.}$$

However, for every inch in a tank of 12 ft. diameter we have 0.49 gallon and therefore used this as a constant to multiply by the height observed.

The fuel consumption of the type of engine used in this test is ¾ pint per horsepower-hour or with the 120-hp. engine it should be 11¼ gal. But since actual observation showed the engine to consume 16.4 gal. per hour, I asked for an efficiency test with the following result:

Total Head	G. P. M.	B. Hp.	W. Hp.	R.P.M.	Efficiency
310.5	1000	130.8	78	1200	59.8

Analysis of the foregoing data will readily disclose the fact that the efficiency was low (guarantee having been 65 per cent.) enough to cause considerable increase of fuel consumption and operating cost because of the high brake horsepower or power required to operate the pump.

For continuous duty it will readily be seen that ordering a 120-hp. engine to carry a load of 130.8-hp. pump is poor engineering. No doubt these engines will operate the pump at the excessive load, but not for very long before burning the bearings and scoring the cylinders. If these outfits are for standby fire duty only, then it will make small difference as to the operating cost, and we are only concerned with the ability of the outfit to furnish water for a short period. Then again, should these pumps be required for continuous duty, it would be safer to use a 40-deg. rise motor at 10 per cent. overload, the overload in this case being but 9 per cent.

Still, would it not have been better engineering to have supplied a 150-hp. prime mover, from the standpoint of operating ability, efficiency and safety, even at the increased cost of the prime mover?

New York City. S. ROSENBERG.

INQUIRIES OF GENERAL INTEREST

Effect of Acid Feed Water on Heating Coils—What effect has acid in boiler-feed water on heating coils? B. H.

Most acids in feed waters are volatilized by heat and swept along with the steam generated in a boiler, and thus liberated in the steam their corrosiveness is intensified. When a steam-heating apparatus is supplied with steam generated from feed water containing sufficient acid impurities to be detrimental to the boiler, the corrosive effect extends to pipes, fittings, coils and radiators, and may result in troublesome leaks, especially at screwed joints.

Horsepower of Alternator—Each of the three ammeters connected in the leads of a three-phase 550-volt alternator read 80 amperes. What is the horsepower delivered at the switchboard? The alternator is rated at 145 per terminal. M. S. K.

The horsepower developed by a three-phase alternator is equal to volts × amperes × power factor × 1.732 ÷ 746. In your question you have not given the power factor. But, for example, assume that the power factor of the circuit is 0.85, then the horsepower = 550 × 80 × 0.85 × 1.732 ÷ 746 = 87 hp. The generator, when loaded to 80 amperes, is supplying only about 55 per cent. of its normal rated load.

Circumferential Cracks in Crankshafts—How can the presence and depth of circumferential cracks in crankshafts be determined and how can a cracked crankshaft be repaired? N. E. M.

To make an inspection for cracks, thoroughly clean the shaft with kerosene, and then upon wiping the surface dry the cracks will be revealed from having become filled with the oil. Their presence will be emphasized by rubbing across the cracks with chalk, red lead, or other coloring matter, afterward wiped from the surface of the shaft. The depth of a circumferential crack cannot be estimated except by removal of metal as by drilling. The only certain repair is by reforging the shaft at a welding heat, followed by very slow cooling.

Cleaning Transformers—We have three 50-kw. transformers stepping down from 2200 to 110 and 220 volts. These transformers have been in use for 13 years, but the oil has never been changed, new oil being added only to make up the losses when necessary. For a number of years these transformers operated at full load, but during the last two years they have been operating considerably under full load. However, the transformers get quite hot. I have examined the inside of the corrugations at the top and find no sediment. I have raised the covers slightly to allow the heat to escape, and this has helped considerably. Do the transformers require cleaning and new oil? How is the cleaning done? R. W. S

The temperature of the transformers as determined by the hand on the outside of the case does not mean anything as to the actual temperature of the windings and cores. As long as the temperature of the oil does not exceed 160 to 170 degrees F., it is safe to assume that the transformers are not operating at an excessive temperature. Since the transformers are 13 years old, the iron in the cores has aged considerable and they will operate at a higher temperature than when new. It is poor practice to open the covers of the transformers, since the action of the air on the warm coil tends to make it sludge, and the oil tends to take up moisture from the air, also by the moisture in the air condensing on the inside of the case and running down into the oil. The coils and cores should be removed from the tanks and thoroughly cleaned with new transformer oil. Do not use gasoline or kerosene on the coils and cores. Care should be exercised in cleaning the coils, since they have been in use for 13 years and no doubt the insulation is not very strong mechanically. Remove the old oil from the tanks and clean them thoroughly with gasoline. Replace the cores and coils in the tanks and fill with new oil. Allowance should be made for the expansion of the oils. About ⅜ in. for each foot of oil in the tank should be sufficient. The oil expands about 4 per cent. for 122 degrees F. rise in temperature.

Steam Space of Horizontal Return-Tubular Boiler—What would be the capacity of the steam space in a return-tubular boiler 72 in. in diameter by 18 ft. long with the water level 24 in. from the top of the boiler? W. N.

The cross-sectional area of the steam space can be found by the formula for determining the area of a segment of a circle, namely,

$$\textit{Area of Segment in sq. in.} = \frac{4H^2}{3}\sqrt{\frac{2R}{H}} - 0.608$$

wherein H = distances from the water level to the top part of the shell, and R = radius of the boiler. As $H = 24$ in. and $R = 72 \div 2 = 36$ in., by substituting in the formula the cross-sectional area of steam space =

$$\frac{4 \times (24)^2}{3}\sqrt{\frac{2 \times 36}{24}} - 0.608$$

= 1188 sq. in., or 1188 ÷ 144 = 8.25 sq. ft.; and having a length of 18 feet, the steam space would have a capacity of 8.25 × 18 = 148.5 cubic feet.

Horsepower of Engine Required to Develop 100 Brake Horsepower—What commercial horsepower size of steam engine would be necessary to drive machinery that requires 100 hp.? P. H. B.

The actual number of horsepower that an engine is capable of developing depends on the size of cylinder, piston speed, the mean effective pressure that can be realized, the design, strength and adjustment of parts, and the power that is lost in overcoming the friction of the engine. On account of the wide variations of these details in present-day practice, commercial ratings of engine power, based simply on the sizes of cylinder are obsolete and likely to be misleading. In establishing the power of an engine, each set of operating conditions much be considered by itself and, as the loss of power from engine friction depends largely upon the operator's attention to such details as adjustments and lubrication that are beyond control of the designer and builder, it is customary to base steam-engine power on the indicated power, or power developed on the piston, thus including the power wasted in engine friction. In average noncondensing engines suitable for developing 100 actual, or brake, horsepower, the engine friction ranges from 10 to 15 per cent., varying with the type, design, workmanship and operating conditions. If it is assumed, when handling a 100-brake horsepower load, that the friction amounts to 12 per cent., the engine would have to develop 100 × 1.12 = 112 indicated horsepower and that would be the required commercial horsepower rating of the engine for the stipulated conditions of operation.

Changes Proposed for the Third Edition National Electrical Safety Code

A TENTATIVE revision of Part I—Rules for the Installation and Maintenance of Electrical-Supply Stations and Equipment, of the National Electrical Safety Code, which, when completed, will be the third edition of this code, has been submitted by the Bureau of Standards, Washington, D. C., to its conferees on the code for consideration. In this tentative third edition no radical changes have been made. The additions are aimed to make the rules more complete. Opportunity is now offered to those interested to submit constructive criticism of the rules. The more important additions are given in the following paragraphs:

126. Motors: (a) Wiring Motors Below 750 Volts.—Motors operating at a voltage of 750 volts or less must be wired with the same precaution as required for industrial wiring carrying the same current.

(b) Protection of Wiring Over 750 Volts.—All apparatus and wiring connected to circuits over 750 volts must be completely inclosed in substantial metal shields or casings, and the conduit must enter and be properly secured to such casings or to suitable terminal boxes screwed or bolted to the casings. Shields, casings and conduits must be grounded as provided in Section 9.

The insulation of the several conductors for motors of over 750 volts, where leaving the metal sheath of cables, must be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pothead or some equivalent method. The conduit must be substantially bonded to the metal casings of all fittings and apparatus connected to the inside circuit. Except where exposed to moisture, a metal sheath need not be provided over splices, but the end of the sheaths must be belled out and sheaths must be grounded around splices by copper wire not smaller than No. 6 A. w. g. and suitable ground clamps.

(c) Motors in Dusty Places.—Inclosed-type motors are recommended in dusty places, being preferable to wooden boxes.

(d) Drip Pans—Where practicable, motors permanently located on wooden floors must be provided with suitable drip pans.

Section 13: Storage Batteries.—Storage batteries, when used to supply current for lighting, heat or power, are subject to the same general requirements as direct-current two-wire generators.

143. Method of Transformer Installations: (a) Location.—Transformers shall be installed according to one of the following methods:

(1) On poles or (when permitted by local authority) on walls of buildings and in compliance with the overhead-line rules. (See rules 238 and 243.)

(2) In outdoor inclosures such that unauthorized persons cannot, without special effort, come in contact with any part of the casing or wiring.

(3) In transformer vaults or rooms which shall be made inaccessible to unauthorized persons. Where the amount of oil in transformer casings is considerable and the transformers are located in buildings used for other than station purposes, they should be placed in suitable transformer vaults.

(4) In rooms containing other equipment. If in stations such transformers should be well insulated from other equipment, and oil sills and suitable arrangements for draining shall be provided.

144. Apparatus with Oil.—Transformers, induction regulators and other electrical apparatus containing an appreciable amount of oil, when installed indoors shall be installed in fireproof inclosures, not having any doors or windows in such a position that burning oil could pass through them onto material or apparatus of a more or less inflammable nature. The inclosures themselves shall not contain any material or apparatus which could take fire from burning oil.

Where such apparatus is installed on a balcony or gallery above other apparatus, a gutter or other means for draining of oil or preventing it from running down on the lower floor shall be provided.

Where such apparatus is installed outdoors, adjacent walls shall be of fireproof material and shall not have any doors or windows in such a position that burning oil could pass through them onto material or apparatus of a more or less inflammable nature. Material or apparatus outdoors which could take fire from burning oil, shall not be placed within 25 ft. of the apparatus in question.

See Rule 107 (b). For requirements for oil gutter in connection with apparatus containing oil.

145. Ground Detectors: (a) Where Required.—All circuits except those as are permanently grounded as provided in Section 9, must be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground connections must be made as provided in Section 9.

(b) Electrostatic Detectors.—Electrostatic ground indicating devices shall be properly protected and be provided with a metallic shield if used on switchboards or near instruments.

150. Electrical Protection: (d) Circuits Exposed to Higher Voltages—If exposed through transformer windings, circuits below 750 volts shall be grounded unless everywhere in grounded conduit or other suitable ducts, or identified and guarded as required for conductors of the higher voltage to which they are exposed.

151. Mechanical and Thermal Protection: (d) Lead Sheathing and Potheads.—Conductors between generators and outside lines shall be in plain sight and supported on approved noncombustible, nonabsorptive insulators or placed in approved metal conduit, tile or other fireproof ducts. Conductors installed in conduit for ducts where exposed to moisture shall be sheathed and the sheathing shall be grounded. Except for systems below 300 volts to ground, the installation of the several conductors where leaving the metal sheath of cables shall be thoroughly protected from moisture and mechanical injury by means of a pothead or some equivalent method.

(e) Conductors Not in Conduit.—Conductors between generators and outside lines shall, where not in conduit, be kept so rigidly in place that they cannot come in contact. Where they pass through floors or fire walls, they shall be carried through individual openings in fire-resisting insulating tubes or their equivalent, and not through a common open space.

(f) Protection Against Excessive Temperatures.—Where insulated conductors are exposed to excessive surrounding temperatures, a special protection shall be provided if the maximum temperature exceeds the maximum safe limiting temperature adopted in the Standardization Rules of the American Institute of Electrical Engineers (Article 677).

157. Temporary Wiring and Precautions During Construction: (b) Construction Precautions.—Where extensions or extensive changes are being made to stations already in operation, the following special precautions shall be taken.

(1) All equipment and apparatus not designed for outdoor operation, but temporarily exposed to the weather or dust, dirt and flyings incident to construction, shall be especially and adequately shielded against such influence.

(2) All equipment and apparatus shall be inclosed or isolated so as to be inaccessible to unauthorized persons, or it shall be installed as required by Part 3, for equipment and apparatus accessible to unauthorized persons.

161. Location of Oil Switches: See Rule 103 for hazardous location. (a) Isolation.—Oil circuit-breakers and switches shall, wherever practicable, be isolated from other switches and electrical apparatus. On circuits over 7500 volts they must be of remote-control type and be inclosed in separate fireproof cells or compartments.

(b) Indoor Inclosures, (c) Drainage on Galleries, (d) Outdoors.—See Rule 144.

165. Where automatic cutouts are required: (a) Constant potential generators, except alternating-current machines and their exciters, and transformers or station auxiliaries, shall be protected from excessive current by suitable automatic cutouts, except as noted hereinafter and in Rule 150.

For two-wire direct-current generators, single-pole protection will be considered as satisfying the foregoing rule, provided the automatic cutout is so located or arranged as to be actuated by the entire generator's current and the action thereof will completely open the generator circuit.

(b) Generators Not Electrically Driven.—For generators not electrically driven supplying a two-wire grounded system, the automatic cutout shall be so placed as to disconnect the generator from all conductors of the circuits.

(c) Generators Used in Balancer Sets.—For two-wire direct-current generators used in conjunction with balancer sets to obtain a neutral for three-wire systems, an automatic cutout shall be installed, which in case of an excessive unbalancing of voltage will operate to disconnect the three-wire system.

(d) Three-Wire Generators.—For three-wire direct-current compound or shunt-wound generators, an automatic cutout other than a fuse shall be placed in each armature lead and so connected as to receive the entire current from the armature. The automatic cutout shall consist of either (1) a double-pole double-coil overload circuit-breaker, or (2) a four-pole circuit-breaker connected in the main and equalizer leads and tripped by means of two overload devices, one in each armature lead. These automatic cutouts shall be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system.

(e) Motors.—Motors shall be provided with cutouts and switches as required for motors in industrial installations by Part 3.

170. Location and Accessibility of Switchboard: (a) General Location.—Switchboards shall where practicable be so placed that the operator will not be endangered by any live or moving parts of machinery or equipment located near the board. They shall be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

(b) Space Above Board.—Switchboards shall be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board. The space back of the board shall be kept clear of rubbish and shall not be used for storage.

(c) Accessibility.—Switchboards shall be accessible from all sides when the connections are made on the back (see Rule 114 for working space), but may be placed against a brick or stone wall when the wiring is entirely on the face.

184. Guarding Live Parts: (c) Insulation of Attachments.—All choke coils or other attachments inherent to lightning-protective equipment shall have an insulation from the ground or other conductors, equal at least to the insulation demanded at other points of the circuit in the station.

Water Power in New Hampshire*

New Hampshire is a mountainous and hilly district extending northwesterly from the Atlantic Coast. The total area is about nine thousand square miles, of which about one-half is forest-clad. The state is drained principally by two river basins, the Merrimac, draining the central and southern portions of the state, and the Connecticut, the northern and western. The greatest elevation in the state is about six thousand feet at Mount Washington.

Rainfall in New Hampshire averages on the whole not far from forty inches per annum. The lowest annual rainfall recorded in the state has been 22.69 in. at Hanover, N. H., in 1871, and the greatest recorded was 121.13 in. on Mount Washington in 1881 (no records available since 1886). There is a marked monthly variation of the amount of water that passes down the rivers. Melting snows of spring cause floods, and the drought of summer sees low water in the rivers. This variation of stream flow is illustrated in the records of flow in the Connecticut at Fairlee, Vt., where it is shown to have been 57,300 sec.-ft., Mar. 28, 1913, and 288 sec.-ft., Sept. 29, 1908, or about one-half of one per cent. of the 1913 flood.

Undeveloped Water Powers

The findings in regard to undeveloped water powers should be of interest and should receive careful consideration. It will be observed that on the Connecticut there are three important water-power sites from which it is estimated that 345,000,000 hp.-hr. can be secured, while on its tributaries there are five additional smaller water powers as yet undeveloped. On the Merrimac and its tributaries it is estimated that there are nine water powers with a total of 145,000,000 hp.-hr. unutilized. No suggestions are herein made as to how these should be developed, as each one must be carefully studied and a financial plan determined for each.

Main Question To Be Determined

It is not possible to state with exactness the amount of hydraulic horsepower of the state, nor is it possible to estimate closely the amount of industrial power generated by coal in plants that do not have water power, but the amount of power at the present power development that would be saved by fairly complete systems of storage would be the equivalent of about 173,000 tons of coal a year in New Hampshire and about 105,000 tons a year to users of power outside New Hampshire, a total of 278,000 tons a year, not including possibilities of the Androscoggin River.

UNDEVELOPED WATER-POWERS ON CONNECTICUT RIVER TRIBUTARIES

Power Site	Head Ft.	Drainage Area* Sq. Mi.	Flow in Cu. Ft. per Sec 50 Per Cent. Time	80 Per Cent. Time	Available Power in hp. hrs.
Mascoma River Total..	140	150	150 Estimated	120 Estimated	9,630,000
Sugar River:					
Claremont	145	175	160	130	10,670,000
Chandler	55	165	150	125	3,810,000
Kelleyville	150	155	140	120	9,750,000
Total	350				24,230,000
Ashuelot River	20	430	365	150	3,080,000
Connecticut River Tributaries, Total	510				36,940,000

*Approximate.
Warren Upham, in Hitchcock's "Geology of New Hampshire," gives 3825 square miles.

DEVELOPED POWER IN NEW HAMPSHIRE

Head	Present Conditions 24-hr. hp. Low water	24-hr. hp. 60% of time	With Additional Economic Storage 24-hr. hp. Low water	24-hr. hp. 60% of time
294 ft.	42,000 hp.	47,000 hp.	47,000 hp.	52,000 hp.

UNDEVELOPED POWER IN NEW HAMPSHIRE

Head	Present Conditions 24-hr. hp. Low water	24-hr. hp. 60% of time	With Additional Economic Storage 24-hr. hp. Low water	24-hr. hp. 60% of time
268 ft.	37,400 hp.	44,180 hp.	44,180 hp.	48,800 hp.

The Connecticut River and its tributaries drain 3120 square miles in New Hampshire, which is but slightly less than the area in New Hampshire drained by the Merrimac River.

The Merrimac, which is fifth in size of New England rivers and first in New Hampshire, receives this name south from Franklin, where the Pemigewasset and Winnepesaukee Rivers unite. The total area drained by the Merrimac and its tributaries in New Hampshire is about 3820 square miles,[1] but as only a small part of the basin above Manchester has been accurately mapped, the statements of area can be regarded only as approximate, and various figures have been used by different engineers.

UNDEVELOPED WATER-POWERS ON MERRIMAC RIVER AND TRIBUTARIES

Power Site	Head, Ft.	Drainage Area, Sq. Mi.	Flow in Cu. Ft. per Sec 50 Per Cent. Time	80 Per Cent. Time	Available Power in hp. hrs.
Moores Falls	25	2900	2800	1600	30,580,000
Bristol Falls	80	760	760	380	26,150,000
Smith River projects...	275	(75 to 85)	...	(60 to 70)	8,550,000
Contocook; Long Falls..	108	379	500	350	24,250,000
No. Br. Contoocook; Hillsboro	157	70	...	...	14,000,000
No. Br. Contoocook; Stoddard	200	35	...	...	8,920,000
Blackwater; Potter Place	25	39	40	20	43,000
Blackwater; Webster ...	200	122	...	...	29,150,000
Southegan; Atherton Falls	50	168	138	46	2,860,000
Total	1,120				144,890,000

*From Report of Commission on Water Conservation and Water Power, New Hampshire.

Limits of Speed and Capacity of Steam Turbines

The Limit of a Single-Unit Turbo-Generator Lies In the Steam End and the Last Wheel Is the Limiting Factor

THE November meeting of the American Institute of Electrical Engineers was held at the Engineering Societies Building in New York on Friday evening, the 14th, under the auspices of the Committee on Power Stations, which had arranged for papers upon the limiting capacity of turbines and generators, one by Eskil Berg, of the General Electric Co., one by J. F. Johnson, and one dealing with the generator, by F. D. Newbury, both of the Westinghouse Electric and Manufacturing Company.

Mr. Johnson's paper, which was the first presented, called attention to the fact that whereas a pound of steam when entering the first stage of a turbine under ordinary conditions has a volume of less than 2½ cu. ft., when passing through the last stage it has a volume of approximately 395 ft. when expanded to 28½ in. vacuum, and 575 cu.ft. when expanded to 29 in. With the employment of high vacua the limit of power of a turbine operating at a given speed will be determined largely by the area obtainable through the last stage.

With materials of infinite strength and rigidity available, it would be possible to build units of infinite capacity; but for a given diameter and blade height the capacity will be limited by chosen maximum values of steam speed through the blades in order to keep the leaving losses, or available energy in the steam discharged to the condenser, within permissible limits. But, for a given diameter and blade height the capacity will be limited by the amount of steam that can pass through the

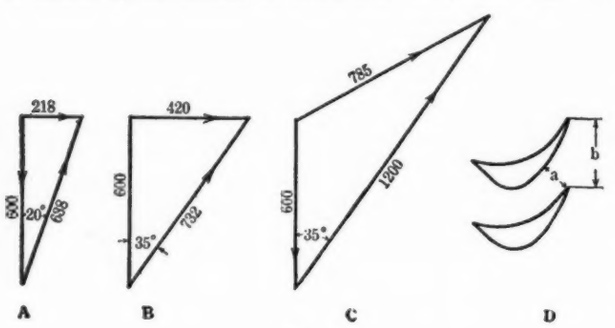


FIG. 1

FIG. 1. VELOCITY DIAGRAMS AND BLADE SPACING OF REACTION TURBINE

available area between the blades, at a velocity that will not be so high as to carry away an unallowable amount of energy in the escaping steam.

Throughout the reaction turbine, with the exception of the last few stages, steam speeds only about 25 per cent. in excess of the corresponding blade speeds, are employed in order to secure maximum efficiency. In the latter stages, however, the volumes become so great that a compromise between maximum theoretical efficiency and physical dimensions becomes advisable by increasing the steam speed sometimes to approximately 100 per cent. in excess of the blade speed. Higher blade speeds tend to improve the efficiency by reducing leaving losses, but generally not as effectively as would larger blade areas, with lower steam velocities and correspondingly increased number of stages.

Having fixed the height of a row of blades, the area of the steam space is dependent upon the angle formed between the center line of the row of blades and the outlet portion of the blades; that is, the space *a*, Fig. 1, D. The smaller this angle is the smaller will be the area, and vice versa. On the other hand, the smaller this angle the higher the efficiency, because of the lesser absolute velocity left in the steam discharged to the condenser. The leaving losses are in Fig. 1A, 218, Fig. 1B, 420 and Fig. 1E, 785 ft. per sec., which is the equivalent of 0.95, 3.5 and 12.3 B.t.u. per lb., respectively.

The steam area is ordinarily expressed as a ratio of the perpendicular distance between blades to the pitch of the blades; that is, the ratio of *a* to *b* in Fig. 1, D. The highest actual efficiency is obtained by keeping this ratio between 0.25 and 0.3, and this is done in all stages, except the last few, in high-vacuum machines, where it is increased to a maximum of 0.5, the equivalent angle being about 35 deg., which includes proper allowance for blade thickness. This ratio has been

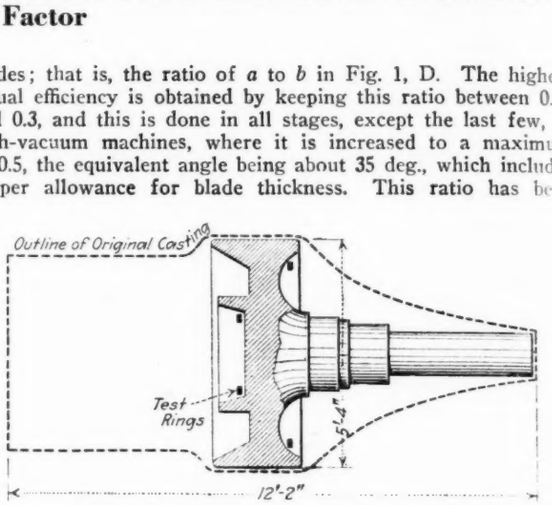


FIG. 2. STEEL CASTING FOR SPINDLE END OF DRUM TURBINE. ALL BUT THE SHADED PORTION IS DISCARDED.

determined upon as a proper compromise between cost of increased blade height and loss of efficiency, due to increased terminal loss. Some European manufacturers have employed ratios as high as 0.65 and 0.7.

While alloy steels possessing exceptionally high physical characteristics are procurable, their high qualities depend on relatively sensitive metallurgical processes, which, in the opinion of some engineers, cannot as yet be carried out by regular workmen as a manufacturing process with a sufficient degree of reliability to justify their use, and until this is done conservatism demands adherence to the lower-strength less sensitive materials. Such materials may, with suitable forms of construction, be safely stressed under the maximum test conditions to within a few thousand pounds of their true elastic limits.

When the construction of the rotor is not limited to any one special form, the design may be varied so as to take full advantage of the low speed in the high and intermediate stages (where low speed must be used in order to secure high efficiency) by employing a drum, the thickness of which may

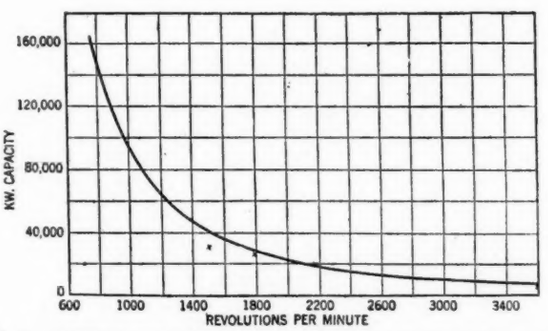


FIG. 3. LIMITS OF CAPACITY OF STEAM TURBINES WITH DOUBLE-FLOW LOW-PRESSURE STAGES

Having steel blades of uniform cross-section stressed to 25,000 lb. per sq. in. at base of blades at 20 per cent overspeed and maximum efficiency at 80 per cent of rating—250 lb. steam pressure—200 deg. superheat—29-in. vacuum referred to a 30-in. barometer—with steam velocity through blades of 1225 ft. per sec. at a volume of 585 cu. ft. per lb.

be varied to keep the stresses within desired limits; while in low-pressure stages, where the stresses are higher, either disks carried on a shaft, or solid disks suitably held together, may be employed. With the solid-disk construction the stresses may be kept within any reasonable limit up to speeds at which the design becomes too massive and expensive.

The steel regularly used by the Westinghouse company for

turbine rotors has a tensible strength of 65,000 to 70,000 lb. per sq. in. elastic limits 22,000 to 25,000 lb. pr. sq. in., elongation 15 per cent. to 18 per cent., reduction of area 20 per cent. to 25 per cent., carbon 0.25, manganese 0.50 to 0.60, silicon 0.25, and not over 0.025 per cent. of sulphur or of phosphorus.

The material is obtained ordinarily in the form of castings, although occasionally as forgings. Fig. 2 shows the form of a casting for a rotor end which is cast vertically with the small end down and allowed to cool very slowly in the sand. After removal the entire upper portion, which constitutes the riser, is cut off, and the casting is then thoroughly annealed by being heated slowly and evenly to a temperature of about 1650 deg. F., and allowed to cool very slowly. It is then rough-machined to within about one-quarter inch of the finished surface, after which it is put in a furnace and heated to about 1100

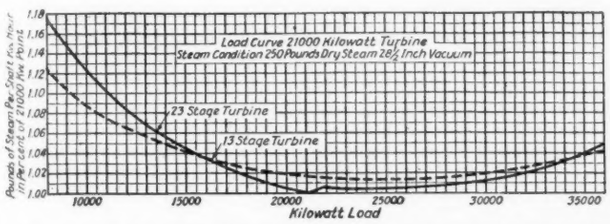


FIG. 4. LOAD CURVES OF 1800-REV. IMPULSE TURBINE WITH 13 AND 23 STAGES

deg. F. and allowed to cool slowly to remove any possible internal stress set up by reason of the material removed in machining. It is then finish-machined and given no further treatment of any kind.

The limit of stress to which this material is subjected is 20,000 lb. per sq. in. when operating at a speed 20 per cent. in excess of the normal. In a case of extreme overspeed the rotor drum, or solid disk, will stretch sufficiently to cause the blading to rub to such an extent as to practically insure its destruction and thus prevent further overspeed before the ultimate strength and elongation of the material is reached.

For any given rotative speed and blade angle the steam capacity or steam area through the blades is directly proportional to the stress at the base of the blade, regardless of the diameter and blade height selected.

This stress can be modified only by unevenly varying the cross-sectional area of the blade, as, for example, by thickening the blade near the base. Also, *for any given stress, the area through the blades will vary inversely as the square of the speed;* that is, if in a speed of 1800 r.p.m. a given stress

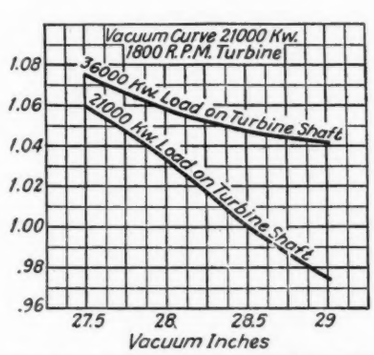


FIG. 5. CURVE OF RELATIVE STEAM RATES WITH DIFFERENT VACUA

and area are obtained, then at 900 r.p.m. the area will be increased four times if the stress is kept constant.

Blading used in impulse stages and in low-pressure reaction stages in which stresses exceed 15,000 lb. per sq. in. at 20 per cent. overspeed, is made of 5 per cent. electric-furnace nickel steel, in which the carbon, sulphur and phosphorus are kept very low. It is really a nickel iron having a very fine close structure. Its physical and chemical characteristics are as follows: Tensile strength, 65,000 lb. per sq. in.; true elastic limit 35,000 lb. per sq. in.; elongation in 2 in. 30 per cent.; reduction of area, 60 per cent.; these being minimum values. Carbon, not over 0.08 per cent.; silicon, not over 0.10 per cent.; phosphorus, not over 0.025 per cent.; sulphur, not over 0.04 per cent.; manganese, not over 0.40 to 0.50 per cent.; nickel, 4.5 to 5.5 per cent.

This material is annealed by heating to 1425 deg. F. and cooled in the open air after rolling into sections required for forming into various blade shapes, and is given no further heat-treatment. The maximum stress of 20 per cent. overspeed to which this material is subject is 25,000 lb. The corresponding stress at normal speed is therefore 17,350 lb., this being 49 per cent. of the true elastic limit and 26½ per cent of the minimum ultimate strength.

For the lower-stressed reaction blading a bronze is employed consisting of copper, 97 to 98 per cent.; tin, 2 to 3 per cent.; phosphorus, 0.03 to 0.07 per cent.

Increased capacity without decrease of rotative speed, or increase of stresses, may be obtained by employing multiple low-pressure stages. This expedient possesses the merit of permitting high-vacuum turbines to be built at speeds and capacities up to approximately the present limits of generator construction, without exceeding moderate diameters, blade lengths and stresses. Fig. 3 shows approximate maximum capacities at various speeds which are physically possible, employing double-flow construction without exceeding the limits of stresses previously given. For equal capacities employing single-flow construction, the stresses would have to be doubled. The points marked *x* at 3600, 1800 and 1500 r.p.m. represent capacities which have already been built. This curve must not be interpreted as indicating suggested practicable present or ultimate limiting capacities of turbines, but merely as showing a physical relation between speed and capacity with given limiting stress values and operating conditions.

FIG. 6. SECTION OF LAST WHEEL OF 23-STAGE, 1800-R.P.M. IMPULSE TURBINE.

An important limit of size and capacity now being approached is that imposed by transportation facilities. The low-pressure rotors of the 30,000-kw. Interborough Rapid Transit Co.'s turbines were shipped with the last-stage blade-carrying elements removed.

If having given a satisfactory reliable design of a given capacity employing low stresses, it is proposed to transform it by modification of design and substitution of higher stresses into a unit of larger capacity, greater blade lengths, and probably greater blade weights, operating at higher speeds, and involving higher centrifugal forces, will be necessary in order to secure the required area. The rotor structure may possibly be shortened somewhat, but unless its total weight is increased nearly in proportion to the increase in stored energy in the individual blade, the unbalanced effect or disturbance caused by one or more blades breaking (which must be recognized as an inevitable occurrence in any turbine) will be greater, imposing greater stresses in the rotor shaft, bearings and bearing supports, and a greater factor of strength will be required to withstand these stresses. The greater blade weight and higher speed will also require increasing the mass of the casing, in order to prevent the blades from permanently injuring and possibly breaking through it if they should fail. The endurance factor of a turbine, when operating under imperfect or abnormal conditions, will be higher in proportion to the ratio of stator mass to rotor mass, and of rotor mass to blade mass. The incorporation in the design of a turbine of features which increase the endurance factor will appreciably increase its cost, but will also to a very much greater extent increase its value to the user.

As sizes become larger, a greater proportion of special equipment and processes becomes necessary, resulting in increased rates of cost, unless accompanied by very material increase in quantity of production. Under present conditions this economic limit of capacity agrees closely with the physical limit of 1500 r.p.m. units.

In the larger low-speed structures the distortions due to temperature changes, and elastic properties of the materials, are such that increased clearances and bracing have to be employed in order to maintain equal reliability and rigidity to a degree which causes the cost per kilowatt for a given efficiency to increase with increasing capacity. Further development of the allied arts and increased demand for larger units will tend to reduce the influence of this limitation factor.

Another factor tending to limit the capacity of single units is the generating capacity loss resulting from suspension of service for inspection or repairs. For example, if a 30,000-kw. unit must be kept out of service ten days for a certain inspection or repair, a 60,000-kw. unit would have to be kept out

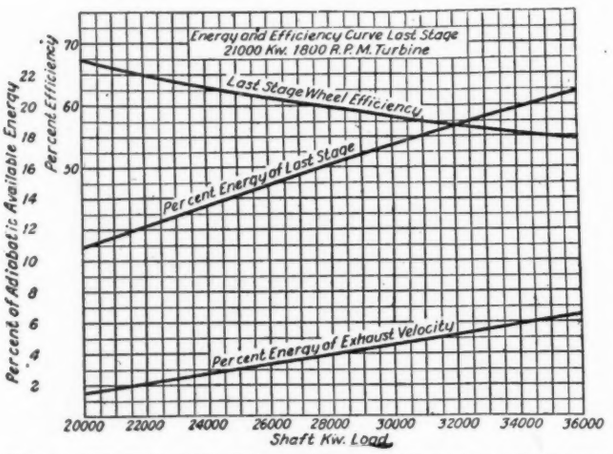

Energy and Efficiency Curve Last Stage
21000 Kw. 1800 R.P.M. Turbine
Last Stage Wheel Efficiency
Per cent Energy of Last Stage
Per cent Energy of Exhaust Velocity
Percent Efficiency
Percent of Adiabatic Available Energy
Shaft Kw. Load
20000 22000 24000 26000 28000 30000 32000 34000 36000

FIG. 7. ENERGY AND EFFICIENCY CURVES OF LAST STAGE

probably fourteen days for a similar purpose, because of the greater time required to handle the larger structure. Therefore, if two 30,000-kw. units were used, and each held out of service ten days, the outage loss would be only 5/7 as great as if a single 60,000-kw. unit was kept out for fourteen days.

In order to avoid the limitations or undesirable characteristics just referred to, a number of turbine units of capacities varying from 30,000 to 60,000 kw. have been built, in which the turbines have been divided into two or three separate compounded elements, each driving its own generator and each capable of operating alone on high-pressure steam in emergencies.

The second paper, presented by Eskil Berg, of the General Electric Co., dealt with the present limits of speed and power of single-shaft Curtiss steam turbines. This limit does not lie in the generator, but is confined to the steam turbine, and the last wheel of the turbine is the limiting feature. The author takes the last wheel of a 1800 r.p.m. turbine, assuming dimension stresses, kind of material used, etc., and designs two turbines, one having 23 stages and the other 13 stages, the first 11 stages of the former being replaced by one two-bucket, both stages using this last wheel, and shows that a turbine can be built having its most economical point at 21,000 kw. under the assumed steam conditions.

Under the conditions of maximum efficiency the last stage absorbs 11½ per cent. of the total available energy with adiabatic expansion, and the wheel efficiency is 66.25 per cent. As the load increases, the work do e in this stage also increases, so that at 36,000 kw. the energy is practically doubled, but with a sacrifice in efficiency of about 18 per cent. for the stage, which naturally lowers the efficiency of the turbine as a whole. The load curves of these turbines are shown in Fig. 4, the conditions being 250 lb. 28½ in. of vacuum of dry-saturated steam. Fig. 5 shows the effect of a change of vacuum from 27.5 to 29 in. upon the 23-stage machine at 21,000-kw. and 36,000-kw. load on the turbine shaft. The vacuum is plotted against the steam consumption, the consumption at 21,000 kw. being taken as unity.

Mr. Berg also explained the importance of area in the last wheel. Efficient action can be accomplished only by using a bucket speed that bears a proper relation to the steam velocity. Consequently, to get the largest capacity we must not only use long buckets, but must move them at a very high speed. In order to obtain good bucket action, the bucket should not be more than about one-fourth as long as the pitch diameter of the wheel. If they are made longer than this, there will be too great a difference in peripheral speed between the base and the tip of the bucket, and the flare becomes so excessive that the space between the buckets and the tip will be so large that the steam can flow between the buckets without doing any work. Fig. 6 represents the last wheel of the 23-stage 1800-r.p.m. machine. The pitch diameter is 88 in., length of bucket 22 in., and the bucket angles 60 deg. entrance and 40 deg. exit. The stresses at normal speed are given in the figure. Elastic limit of material, 55,000 lb. per sq. in. The material used in the wheel and bucket is quenched and tempered 3 per cent. nickel steel.

Cause of Wheel Breakages

In some of the first large machines of the type here discussed serious trouble has developed through the formation of cracks in the forged wheels. Such cracks have caused wheels to break in three important installations. The cracks that have formed in these wheels have started at holes in the wheels, provided either for balancing steam pressures on the two sides of the wheel or for the attachment of balance weights. The occurrence of these accidents naturally gave rise to much alarm, uncertainty and difference of opinion as to the cause of the trouble. Calculations showed that the wheels that broke were less stressed than many that were made from weaker metal and had operated for longer periods of time. Holes in a centrifugally stressed wheel greatly increased the fiber stress in the vicinity of the hole itself, but such conditions had not caused the formation of cracks in large numbers of wheels in which localized high stresses existed. Many evidences have now shown that the trouble with these wheels has not resulted from stresses in excess of those that had been previously found to be practicable, but had been caused by fluttering and vibration of the wheels, which had become possible through the lightness and thinness of their construction. Such vibration gave a periodic character to the stresses normally imposed, and so gave rise to the formation of fatigue cracks.

In machines of this type relatively light and narrow buckets have been used, and the wheels have been proportioned with a view to ample centrifugal strength, but with maximum economy of space and weight. Consequently, these wheels have had much less lateral distance than wheels used in turbines of previous types. To overcome such troubles as have developed it is necessary simply to make the wheels stiffer and to put in holes in parts of the wheel near the hub, where a suitable reinforcement of thickness can be provided which

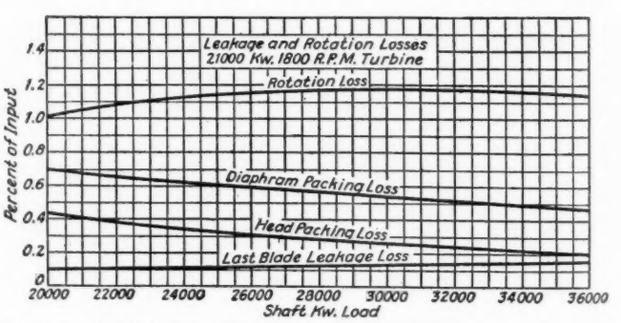

Leakage and Rotation Losses
21000 Kw. 1800 R.P.M. Turbine
Rotation Loss
Diaphram Packing Loss
Head Packing Loss
Last Blade Leakage Loss
Percent of Input
Shaft Kw. Load
20000 22000 24000 26000 28000 30000 32000 34000 36000

FIG. 8. LEAKAGE AND ROTATION LOSSES OF ASSUMED TURBINE IN PER CENT OF OUTPUT

both stiffens the wheel and reduces the stresses near the hole. Very slight changes of this kind make a great difference in the vibrating characteristics of such wheels, and the proportions used are such that they can easily be brought to the same standards of safety in these respects as have long prevailed in wheels of heavier construction in machines having less numbers of stages.

Experience has shown that in the absence of a tendency to form fatigue cracks through vibration, overspeed in such turbine wheels involves relatively little danger as compared with other types of high-speed machinery. Experimentally, and in actual service, wheels have been stretched to a considerable degree of enlargement without the formation of any cracks,

and such stretching is a normal condition if the cracks do not exist.

It has been discovered that such fluttering or vibration of the web of wheels has not only been responsible for the formation of fatigue cracks in the wheels themselves, but has also caused loosening and breakage of buckets. The cure for these difficulties is to use stiffer wheels, and such wheels can carry stiffer buckets, so that the whole structure is incapable of vibration of any amplitude through such forces and periods as arise from the conditions of operation.

Fig. 7 gives the energy and efficiency curves of this last stage. It will be noticed that at the most efficient point, (21,000 kw.), this stage absorbs 11.5 per cent. of the total adiabatic available energy, and that the wheel efficiency is 66.25 per cent. The energy represented by the exhaust velocity which is all wasted in the condenser is 1.5 per cent. of the total energy. As the load increases on the turbine shaft, the energy in this stage also increases, decreasing its efficiency until at 36,000 kw. the energy in the last stage is 20.9 per cent. of the total energy. The wheel efficiency, however, has been reduced to 54.2 per cent. and the energy represented by the exhaust velocity has been increased to 6.4 per cent. This great amount of work in the last stage at such poor efficiency naturally lowers the efficiency of the whole turbine, and in this case the efficiency at 36,000 kw. is 5 per cent. lower than at 21,000 kw.

Fig 8 shows leakage and rotation losses of the same turbine in percentage of input.

From the foregoing it will be seen that for 1800 r.p.m., a turbine can be designed efficiently for 21,000 kw., which, with a sacrifice of efficiency can deliver 36,000 kilowatts.

Fig. 9 gives a load curve of the smaller 3600 r.p.m. turbine. The water rates are here given in reference to that of the larger machine, the load of 5000 kw. corresponding to that of 20,000 kw. on the 1800 r.p.m. turbine. This turbine has only five stages, one two-bucket wheel in the first stage, the other four stages having single-bucket wheels. The first wheel has a pitch diameter of 35.5 in., and the remaining four wheels a pitch diameter of 51 in. The bucket height of the last wheel is 9.125 in., the turbine being designed for a maximum of 6250 kilowatts.

The reason for such a discrepancy in the number of stages calls for explanation. As the output of a turbine, keeping approximately the same stresses, goes up inversely as the square of the revolutions per minute, if the same number of stages could be used and clearance and all dimensions proportionately reduced, a 5000-kw. machine at 3600 r.p.m. could be made nearly as efficient as a 20,000-kw. machine at 1800 r.p.m., and developments of smaller multistage machines at the

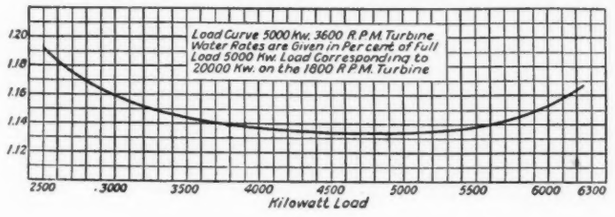


FIG. 6

FIG. 9. LOAD CURVE OF 5000-KW., 3600 R.P.M., 5-STAGE TURBINE

Lynn works have already been made which approximate such possibilities. Constructions, however, that are practicable on a large scale are not practicable on a small scale, and consequently there are difficulties in getting the space economy in small high-speed machines which would be necessary for accomplishing the result stated. One of the difficulties has lain in the construction of diaphragms, the casting in of nozzle partitions being easy in a large diaphragm and very difficult on a small one. We are working upon types of diaphragms and other parts which may make possible the development of multistage high-speed machines which afford improved degrees of economy.

If a 10,000-kw. turbine is designed for 1800 r.p.m., the only change necessary would be to make the nozzle and bucket heights about half the height of those in the 20,000-kw. unit. This reduction in height of buckets and nozzles would affect the weight, size and cost of the turbine very little as compared with the 20,000-kw. unit. In regard to economy, the lower bucket heights would reduce the rotation loss somewhat but far from 50 per cent. The diaphragm packing loss, head packing losses and bearing losses would be practically the same as on the 20,000-kw. unit, so that while a turbine designed for 10,000 kw. would be more economical than the large turbine running at half load, the difference would be small, being only about 6 per cent.

It will be seen from this paper that for a given speed there is one particular size of turbine that can be designed to be most economical as to steam consumption, weight, space, and price per kilowatt. Even if a size smaller than this is required, it would in many instances pay for the central station

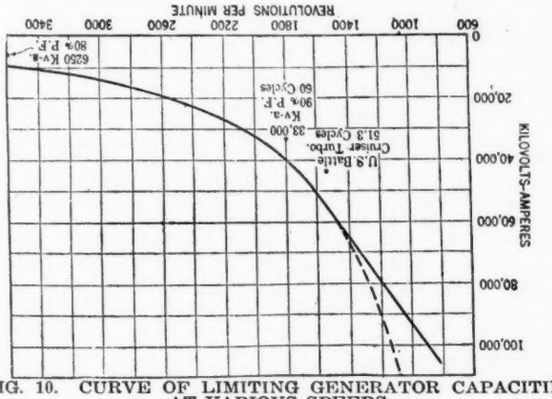


FIG. 10. CURVE OF LIMITING GENERATOR CAPACITIES AT VARIOUS SPEEDS

to install the larger unit, even though it would have to run at reduced load for some time before the station load increased sufficiently to utilize the full capacity.

Mr. Newbury's paper dealt with the electrical portion of the unit. With speeds of 1200 r.p.m. and lower the stator is the limiting member, while with higher speeds the rotor is the limiting member. American design practice has established 400 ft. per sec. as an upper limit of rotor peripheral speed. The most effective rotor diameter is not necessarily the largest diameter. To obtain maximum output at a given speed, the rotor proportions must be chosen to properly balance mechanical stresses, rotor ampere turns and flux.

The maximum length of coil is determined by such factors as ventilation, bearing temperatures, critical speeds and limits to weight imposed by forging and transportion facilities. Fig. 10 shows present limits to kilowatt-ampere rating at speeds from 3600 to 900 r.p.m. These limiting values are given as indicating present boundaries to knowledge and experience, rather than as real physical or other limits that cannot be exceeded.

Mechanical forces, due to short-circuit current, and damage caused by armature winding failures, are no greater in the very large generators, indicated by Fig. 10, than in present-day 20,000 — and 30,000 — kv.a. units.

Proposed Pension Plan for Employees

Retiring employees on pensions when they have qualified by long service and reached an age when their labor is not so effective as that of younger members of the industrial ranks, was touched upon by President R. H. Ballard, of the National Electric Light Association, in his speech to the convention of the Southeastern Section held at Asheville, N. C., on Sept. 18.

By a recent action taken by the Railroad Commission, the regulating body of the State of California, Mr. Ballard said that he believed that a new principle in the jurisprudence of the United States had been enunciated. One of the largest electrical companies in that state had applied to the regulating body for authority to put into effect a pension contract granting pensions to all of its employees upon reaching the age of sixty years, after a twenty-year period of continuous service. The commission, in confirming this application, gave the pension plan the force and effect of a contract binding and collectible at law and permanent beyond the power of any future management of the corporation to eliminate and beyond the power of any future regulating body to abrogate.

Fuel-Oil Storage Rules, National Board Fire Underwriters

Individual Oil-Burning Equipments for Other Than Household Purposes

APPARATUS using oil for fuel, however safeguarded, introduces a distinct increase in hazard, which should be recognized. Where used, the following rules should be rigidly observed.

All oil used for fuel purposes under these rules shall show a flash test of not less than 150 deg. F. (Abel-Pensky flash-point tester). This flash point corresponds closely to 160 deg. F. (Tagliabue open cup tester), which may be used for rough estimations of the flash point.

Capacity and Location of Tanks

a. In closely built-up districts or within fire limits tanks to be located underground with tops of tanks not less than 3 ft. below the surface of the ground and below the level of the lowest pipe in the building to be supplied. Tanks may be permitted underneath a building if buried at least three feet below the basement floor, which is to be of concrete not less than 6 in. thick. Tank shall be set on a firm foundation and surrounded with soft earth or sand, well tamped into place. No air space shall be allowed immediately outside of tanks. Tank may have a test well, provided the test well extends to near the bottom of the tank, and the top end shall be hermetically sealed and locked except when necessarily open. When the tank is located underneath a building, the test well shall extend at least 12 ft. above the source of supply. The limit of storage permitted shall depend upon the location of the tanks with respect to the building to be supplied and adjacent buildings, as given in the following table:

TABLE I. PERMISSIBLE AGGREGATE CAPACITY IF LOWER THAN ANY FLOOR, BASEMENT CELLAR OR PIT IN ANY BUILDING WITHIN RADIUS SPECIFIED

Capacity Gallons	Radius Feet
Unlimited	50
20,000	30
5,000	20
1,500	10
*500	Less than 10

*In this case tank to be entirely incased in 6 in. of concrete.

6. When located underneath a building no tank to exceed a capacity of 9000 gal. and basement floors are to be provided with ample means of support independent of any tank or concrete casing.

c. Outside of closely built-up districts or outside of fire limits, above-ground storage tanks may be permitted as specified in Rule 1, provided drainage away from burnable property in case of breakage of tanks is arranged for or suitable dikes built around the tanks. When dikes are employed the distances specified in Table I are to be taken as distances to nearest points of dikes.

When aboveground tanks are used, all piping must be arranged so that in case of breakage of piping the oil will not be drained from tanks. This requirement prohibits the use of gravity feed from storage tanks. Aboveground tanks of less than 1000 gal. capacity without dikes may be permitted in case suitable housings for the protection of the tanks against injury are provided.

Material and Construction of Tanks

a. Tanks must be constructed of iron or steel plate of a gage depending upon the capacity as specified in the following tables:

TABLE II. UNDERGROUND TANKS INSIDE OF SPECIFIED FIRE LIMITS, OR WITHIN TEN FEET OF A BUILDING WHEN OUTSIDE SUCH LIMITS

Capacity (Gallons)	Minimum Thickness of Material
1 to 560	14 U. S. gage
561 to 1,100	12 U. S. gage
1,101 to 4,000	7 U. S. gage
4,001 to 10,500	¼-in.
10,501 to 20,000	5/16-in.
20,001 to 30,000	⅜-in.

b. All joints of tanks must be riveted and soldered, riveted and calked, welded or brazed together, or made by some equally satisfactory process. To be tight and sufficiently strong to bear without injury the most severe strains to which they are liable to be subjected in practice. The shells of tanks to be properly reinforced where connections are made, and all connections should as far as practicable be made through the upper side of tanks above oil level.

TABLE III. UNDERGROUND TANKS OUTSIDE OF SPECIFIED FIRE LIMITS, PROVIDED THE TANKS ARE TEN FEET OR MORE FROM A BUILDING

Capacity (Gallons)	Minimum Thickness of Material
1 to 30	18 U. S. gage
31 to 350	16 U. S. gage
351 to 1,100	14 U. S. gage
1,101 to 4,000	7 U. S. gage
4,001 to 10,500	¼-in.
10,501 to 20,000	5/16-in.
20,001 to 30,000	⅜-in.

c. Tanks shall be thoroughly coated on the outside with tar, asphaltum or other suitable rust-resisting material.

Note: The protection required for tanks will depend on the condition of the soil in which they are installed. When the soil is impregnated with corrosive materials, tanks should be made of heavier metal in addition to being protected as specified above.

Fill and Vent Pipes

a. Each underground storake tank having a capacity of over 1000 gal. to be provided with at least 1-in. vent pipe extending from the top of the tank to a point outside of building. Vent pipe to terminate at a point at least 12 ft. above the level of the top of the highest tank car or other reservoir from which the storage tank may be filled. Terminal to be provided with a hood or gooseneck protected by a noncorrodible screen and to be located remote from fire escapes and never nearer than 3 ft., measured horizontally and vertically, from any window or other opening. Vent pipes from two or more tanks may be connected to one upright, provided the connection is made at a point at least one foot above level of source of supply.

b. Tanks having a capacity of less than 1000 gal. may be provided with combined fill and vent pipes so arranged that the fill pipe cannot be opened without opening the vent pipe, these pipes to terminate in a metal box or casing provided with a lock.

c. Fill pipes for tanks which are installed with permanently open vent pipes must be provided with metal covers or boxes which are to be kept locked except during filling operations.

d. Fill and vent pipes for tanks located under buildings are to be run underneath the concrete floor outside of building.

Indicator

Some device for indicating the level of the oil is desirable. Where used, such attachment shall be connected through substantial fittings so as to minimize exposure of the oil, and devices the breakage of which will allow the escape of oil must not be used.

Filters

Suitable filters or strainers for the oil should be installed and preferably located in the supply line before reaching the pump. Filter to be arranged so as to be readily accessible for cleaning.

Feed Pumps

a. Must be of approved design, secure against leaks.

Note: Stuffing-box, if used, should be provided with a removable cupped gland designed to compress the packing against the shaft and arranged so as to facilitate removal. Packing affected by the oil must not be used.

b. To be arranged so that dangerous pressures will not be obtained in any part of system, and it is further recom-

mended that feed pumps be interconnected with pressure air supply to burners to prevent flooding.

Gage Classes and Pet-Cocks

Glass gages, the breakage of which would allow the escape of oil, are to be avoided. If their use is necessary, they should have substantial protection or be arranged so that oil will not escape if broken. Pet-cocks must not be used on oil-carrying parts or system.

Receivers or Accumulators

a. If used, they must be designed so as to secure a factor of safety of not less than 6. Must be subjected to a pressure test of not less than twice the working pressure.

b. The capacity of the oil chamber must not exceed 10 gal.

c. To be equipped with pressure gage.

d. To be provided with an automatic relief valve set to operate at a safe pressure and connected by an overflow pipe to supply tank, and so arranged that the oil will automatically drain back to the supply tank immediately on closing down the pump.

Standpipes

a. If used, their capacity shall not exceed 10 gal.

b. To be of substantial construction equipped with an overflow, and so arranged that the oil will automatically drain back to the supply tank on shutting down pump, leaving not over one gallon, where necessary, for priming, etc.

c. If vented, the opening should be at the top and may be connected with the outside vent pipe from storage tank, above level of source of supply.

Piping

a. Standard full-weight wrought iron, steel or brass pipe with substantial fittings to be used and to be carefully protected against injury. Piping under pressure must be designed to secure a factor of safety of not less than 6, and installation to be tested to a pressure not less than twice the working pressure.

b. Piping to be run as directly as possible, and laid so that the pipes are pitched toward the supply tanks without traps.

c. Overflow and return pipes to be at least one size larger than the supply pipes, and no pipe to be less than ½-in. pipe size.

d. All connections to be perfectly tight with well-fitted joints. Unions, if used, to be of approveed type having at least one face of the joint made of brass and having conically faced seats, obviating the use of packing gaskets.

e. Pipes leading to the surface of the ground to be cased or jacketed where necessary to prevent loosening or breakage, and proper allowance should be made for expansion and contraction, jarring and vibration.

f. Connections to outside tangs to be laid below the frost line and not to be located near nor placed in same trench with other piping.

g. Openings for pipes through outside walls to be cemented and made oil-tight.

Valves, Etc.

a. Readily accessible shutoff valves to be provided in the supply line as near to the tank as practicable and additional shutoffs to be installed in the main line inside building and at each oil-consuming device.

b. Controlling valves in which oil under pressure is in contact with the stem to be provided with stuffing-box of liberal size, containing a removable cupped gland designed to compress the packing against the valve stem and arranged so as to facilitate removal. Packing affected by the oil must not be used.

c. The use of approved automatic shutoffs for the oil supply in case of breakage of pipes or excessive leakage in building is recommended.

Henry C. E. Meyer gave an interesting paper on "The Application of Standardization and Graphical Methods to the Design of Cylindrical Return Tubular Boilers," before the recent meeting of the Society of Naval Architects and Marine Engineers, 29 W. 39th St., New York City. The design relates to Scotch boilers, those with separate and those with common combustion chambers. There is a scarcity of published data on performance of these boilers, and Mr. Meyer gives as guide performances during voyages of a tramp steamer.

Trade Unionism as Viewed by The American Association of Engineers

The American Association of Engineers, through its board of directors, recognizing the many fundamental differences between the principles and objectives of the trade union and of an organization of professional men, expresses the opinion that an engineer cannot subscribe to the tenets of both. The position of the association is defined in the following paragraphs:

The engineer is the medium through which both capital and labor are used in production and in industrial development. The aim of the profession is to advance civilization and render the highest service to society. Except when their acts further this aim, it is an advocate of neither capital nor labor.

Production should be increased—not limited. The profession cannot support strikes or lockouts or any other method that may benefit any class at the expense of the nation as a whole. They are unsound and must inevitably lead to economic disaster. The law for supply and demand for men or material must ultimately prevail. Attempts may be made to limit the supply of either, but looking toward the upbuilding of civilization we believe rather in increasing the demand through the promotion of legitimate enterprises.

Rewards should be according to ability, initiative and constructive effort. Men are not equal in these respects. Each man should be encouraged to do his utmost and be given compensation according to ability and will to increase production and to achieve large results.

The engineer, as an educated professional man, believes in basing his claims for proper and just reward for his services upon the justice of the facts presented, upon enlightenment of public opinion, upon loyalty between employer and employe, and upon the underlying fundamental desire of the great majority to do what is fair and right when the merits of the case in question are clearly presented and demonstrated. The board believed in organized representation for the correction of wrong, the advancement of the profession and service to the public, but were opposed to methods inconsistent with the dignity of the profession and which would lesson public confidence.

Fiftieth Anniversary Dinner W. S. E.

On the evening of Dec. 2 at the Morrison Hotel, Chicago, the Western Society of Engineers held its fiftieth anniversary dinner and reunion. The banquet was a record breaker, over 600 sitting at the tables. A goodly proportion were of the new members obtained in the recent drive, and they in particular were greeted and made welcome by President Baldwin, acting as toastmaster. Incidental to the program Secretary Nethercut made the interesting announcement of a fund of $5000 offered by R. W. Hunt, the income of which at 5 per cent. was to be set aside as a yearly prize for the best paper presented to the Society on subjects relating to the manufacture of iron or steel.

E. M. Hughman, honorary secretary of the Indian Society of Engineers, was in attendance and made a few extemporary remarks concerning the recent consolidation of engineers in India into the above named association. The new movement resembles that of the American Association of Engineers in this country. Of a prospect list of 10,000 they now have 35 per cent.

R. E. Patterson Kline gave the address of the evening on "Who Owns Your Business?" dealing with the present troublesome times, and the rights of private property which temporarily were being submerged. The old ideas of 1914 concerning individualism were gone forever. In the present period of fluidity the pendulum was swinging in the opposite direction. The existing problems should be viewed in the light of history, and tempered, sane propaganda should be given the earliest and widest distribution possible to combat the radical movement. Capital, brawn and brains, the three big factors needed in industry, each had a place, and for the best interests of all mere brawn cannot dominate.

Throughout the dinner the Universal Quartette rendered numerous selections and led community singing. A series of vaudeville acts closed the entertainment of the evening.

Accidents to Two Turbines

A 3000-kw. horizontal Curtis turbine installed in the plant of the Connecticut Light & Power Co., Waterbury, Conn., eight years ago, completely wrecked itself at 1:15 p. m., Nov. 18, killing two men, injuring others, and doing damage to other turbines and the power house building. The machine ran at 1800 r.p.m. and had a rim speed of about 400 ft. per sec., which is much lower than velocities which are safely carried upon modern machines by the same builders.

Some of the wheels were split apart, others are badly battered and broken at their peripheries; the shaft was broken and the bolts in the coupling bent. The turbine end of the shaft was hurled upward, just clearing the adjacent turbine, but bending the lifting bolts in the top of its casing; the broken shaft continued on, striking and bending the crane rail and landing outside the turbine room. Exclusive of the generator stator and rotor the heaviest piece of broken metal probably does not weighs more than 500 lb.

Viewing the wreck and the turbine room it seems remarkable that the severe damage was confined to one machine. This turbine was one of six, all set transverse of the room; it was number three, thus having two machines to the north and three to the south of it. The building walls and roof, the latter of 5-in. thick reinforced concrete, are perforated in numerous places where chunks of metal burst through. The engineer's office, which is at the south end of the turbine room, was damaged, pieces of metal breaking through the wall and door. Fortunately no one was in the office at the time. An oiler standing on an elevation near the power house was looking in the direction of the plant when the machine let go. He saw several large pieces of it burst through the concrete roof and land into the river nearby. One piece of metal, said to weigh about 500 lb., was hurled through the building and continued on some three or four hundred yards into the second story window of the nearby brass works.

News comes to us also of the failure of a 4000-kw., 6-stage, 1800 r.p.m. unit at the Ashley Street Station of the Union Electric Light & Power Co., at St. Louis. This was installed in 1911 and was the second of the horizontal type put out.

Investigations of both accidents are under way and we hope to print further particulars as to their cause.

Coal Crisis Now Confronting Chicago and Northwest

As this issue goes to press the coal situation in Chicago and the Northwest has reached a critical stage. This section of the country depends almost entirely on bituminous coal, and therefore is hit hardest by the coal strike.

At present the soft-coal production is only 600,000 tons daily, as compared with a normal production of over 1,800,000 tons. Almost half the total production is by non-union labor, but this is in fields far removed from the Middle West, and so far little of this coal has been diverted to the districts in greatest need, due partly to lack of cars. In fact, at present only 20 per cent. of the normal supply is being received in Chicago, and from the latest reports there are available only 8000 carloads to take care of a population of 30,000,000 people in the Northwest.

According to Samuel Insull, president of the Commonwealth Edison Co., and representing the subsidiary public utility companies of Illinois, there is on hand at the plants of the Commonwealth Edison Co. less than 25 days' supply of coal. This makes a large reduction in consumption of electricity imperative.

The committee appointed by the Public Utilities Commission to investigate the situation has recommended the following drastic regulations:

1. All unnecessary interior and exterior electric lights, including show windows, signs, etc., be stopped.

2. Suburban and local transportation reduced to the least number of runs to accommodate traffic requirements, reducing heat also.

3. Work shops, industrial establishments, wholesale business, mercantile establishments, storage warehouses (cold storage excepted) to be open not more than from 8 a. m. to 3:30 p. m.

4. Loop retail establishments to be open from 11 a. m. to 5:30 p. m., 6½ hours; outlying retail stores to be open from 12 noon to 6:30 p. m.

5. Office buildings, banks, etc., to be open from 9 a. m. to 3:30 p. m. only.

6. Limit theaters to six performances a week, excepting moving picture houses.

It is predicted that unless the situation improves within the next few days still greater restrictions will be forthcoming.

Mr. F. S. Peabody, president of the Peabody Coal Company, voicing the opinion of operators, believes that the time has come for the Government to maintain a position of "hands off" and allow the matter to be adjusted between the operators and the miners with a view to getting production established, even though it does mean paying the miners a higher wage than the Government has stood for. Mr. Peabody pointed out that it is impossible to replace the striking miners in the Illinois field on account of a law which prescribes that no miners shall work without two years' previous experience. The miners in these fields in 1914 received 61 cents per ton of coal mined. They are now receiving 85 cents per ton, and if the recommendation of a 14 per cent. increase, as urged by Mr. Garfield, are adopted, this would raise the rate to 95 cents per ton mined. According to Mr. Peabody an able-bodied miner can turn out 20 tons a day, bringing his daily wage up to something like $18. Statistics for the past year show that in one of the large coal companies in this district employing about 20,000 men, there were on an average of 1800 voluntarily idle at all times.

Mr. Charles Piez, formerly chairman of the U. S. Shipping Board, and now chairman of the Chicago Coal Committee, disagrees with Mr. Peabody, and maintains that the Illinois law which puts the coal situation into the hands of organized labor should be repealed at once; that the federal and state governments should coöperate, and that the matter is not one for the operators and the miners to adjust between themselves and pass the burden on to the consumer, but that it is purely a question for the people to take into their own hands, through the agencies of the Government, and that all individual interests should be subordinated to the public welfare.

New Publications

GOVERNORS AND THE GOVERNING OF PRIME MOVERS. By W. Trinks, M. E., Professor Mechanical Engineering, Carnegie Institute of Technology. Published by D. VanNostrand Co., New York. Cloth, 6 x 9 in.; xviii + 236 pages.

This book aims to supply a knowledge of the fundamental principles of governors in a form available to designing and operating engineers. A discussion of the theory of governors leads to considerable mathematics, but in an appendix the author has given elementary derivations of those parts which, as given in the text, require a knowledge of higher mathematics. There are a number of illustrations, all of which, however, are in the form of diagrams, as it is no part of the author's plan to discuss actual forms and details, but rather to present fundamentals. There is a short historical sketch, followed by a discussion of the action of governors alone, and later a discussion of the reaction between the governor and the prime mover. There is also a chapter on governor troubles and their remedies. A bibliography containing 83 titles is added for the convenience of those who wish to study the subject more completely.

STEAM TURBINES. By James Ambrose Moyer. Fourth edition. Published by John Wiley & Sons, New York City. Cloth, 9 x 6 in.; 406 pages.

The chief additions to this volume embodied in the fourth edition are those that relate to methods of governing the calculation of the strength of disk type of blade wheels, and the recent developments in marine practice. There are, of course, many other changes and additions to other chapters. This book is too well known to require lengthy review here. The fourth edition heightens the high standard of this book.

PRACTICAL MATHEMATICS FOR HOME STUDY. By Claude Irwin Palmer, Associate Professor of Mathematics, Armour Institute of Technology. Published by McGraw-Hill Book Co., Inc., New York. Flexible cloth, 5 x 8 in.; 493 pages.

The purpose of this volume is to supply a textbook of mathematics for use in classes of adults engaged in practical work, as well as a guide for the man who is studying mathematics by himself. There are four parts, devoted to arithmetic, geometry, algebra and trigonometry. No attempt is made to treat any subject exhaustively, but enough explanation is given to enable the man who is unfamiliar with mathematics to obtain a working knowledge sufficient for the solution of the problems confronting the practical worker. The author has succeeded in covering a large field very clearly and yet in compact form. A feature of the work is the large number of exercises or problems supplied.

AMONG INDUSTRIAL WORKERS. Published by the Industrial Department of the International Committee Young Men's Christian Association, New York. Cloth, 6 x 9 in.; 175 pages.

This is a handbook of Young Men's Christian Association work in industrial fields. The book, which contains 22 chapters, deals with the Association's relation to industry, both employers and employees, takes up the cooperation with other agencies, special groups of industrial workers, Americanization, the religious program in industry, social activities, showing how work of this kind may be carried on by the Association. Chapter 18 deals with the suggested industrial policies for state committees. The book embodies the experience of the Association which, as everyone knows, has been wide. It would seem that the book is a necessity to any industrial Y. M. C. A. secretary, and those who are carrying on industrial welfare work will find the book of material aid.

THE GASOLINE AUTOMOBILE. By Hobbs, Elliott and Consoliver. Published by McGraw-Hill Book Co., Inc., New York. Cloth, 6 x 9; 483 pages.

This is a second edition of a book under the same title by George W. Hobbs and Ben G. Elliot. The present edition has been completely revised and rewritten by Ben G. Elliot and Earl L. Consoliver, professor and assistant professor, respectively, of mechanical engineering, University of Wisconsin. The purpose of the book is to enable the average automobile owner to understand the mechanical principles underlying the operation of his car. This second edition has been prepared to keep in touch with the developments in automobile practice. Six chapters have been added and many new illustrations are included. No attempt has been made to cover all makes and models of cars, but the idea of giving instruction in fundamental principles has been followed.

Personals

William Tietze has resigned as chief engineer of Cudahy Bros. Co., to assume the position of manager of the Citizens Light, Heat and Power Co., Canby, Minn.

Harry Himelblau announces the initiation of a consulting engineering practice, in addition to his duties as mechanical engineer with the Armour Grain Co., in the company's offices at 208 So. La Salle St., Chicago.

Harry J. Lindsley and William F. Jennings have been made vice presidents of the Bound Brook Oil-Less Bearing Co., of Bound Brook, N. J., in recognition of their services to the company. Mr. Lindsley has been western sales manager for the last seven years and Mr. Jennings eastern sales manager for the last five years.

John W. Price, for a number of years chief engineer of Haddon Hall, Atlantic City, N. J., and a past president of Atlantic Council No. 4 of the American Order of Steam Engineers, has been appointed a member of the State Examining Board of Steam Engineers of the state of New Jersey.

Frank G. Phegley, who has been manager of the Cleveland office of Warren Webster & Co. for nine years, has resigned to enter the professional field as consulting engineer in heating and ventilating work. Clyde W. Colby has been appointed to succeed him assisted by William Roebuck, Jr., of the home office sales engineering force.

Herbert J. Flagg, formerly captain of coast artillery, has been appointed chief engineer of the Public Service Commission of Washington, with headquarters at Olympia, to succeed D. F. McCurrach, resigned. Captain Flagg has been on the engineering staff of the commission since 1915.

Dugald C. Jackson and Edward L. Moreland announce that after their absence in France in the Corps of Engineers, United States Army, they have now resumed their practice as consulting engineers under the firm name of Jackson & Moreland with offices at 387 Washington St., Boston, Mass. Arthur L. Nelson has become associated with the firm for the purpose of giving particular attention to the design and the supervision of construction of power plants and transmission systems.

New Construction

PROPOSED WORK

Mich., Highland Park (Detroit P. O.)—The Hamilton Theatre Co., c/o C. Howard Crane, Arch., Huron Bldg., Detroit, plans to build a 3 story, 68 x 170 ft. theatre and office building on Highland Ave. A complete steam heating system will be installed in same. Total estimated cost, $300,000.

Mich., Highland Park (Detroit P. O.)—John H. Kunsky, Inc., 501-520 Madison Theatre Bldg., retained C. Howard Crane and E. G. Kiehler, Arch., Huron Bldg., to prepare plans for the construction of a 2 story, 100 x 180 ft. theatre on Hamilton Blvd. A steam heating and ventilating system will be installed in same. Total estimated cost, $250,000.

Mich., Highland Park (Detroit P. O.)—The Tuxedo Theatre Co., c/o L. W. Lehmkuhle, 1254 Philadelphia Ave., Detroit, plans to construct a 2 story, 135 x 140 ft. theatre on Hamilton Blvd. A steam heating and forced ventilation system will be installed in same. Total estimated cost, $200,000.

Mich., Niles—The city retained C. W. Hubbell, Engr., 2348 Penobscot Bldg., Detroit, to prepare plans and estimates for a water system. Work will include sinking wells, laying new pipe mains and installing motor driven centrifugal pumping units. Total estimated cost, $75,000.

Mich., Owosso—The city is having plans prepared by H. Riggs, Engr., Engineering Bldg., Ann Arbor, for the installation of a steam pumping unit, having a capacity of 3 to 5,000,000 gallons per day, also an electric driven air compressor having a capacity of 1200 cu. ft. per minute.

Mich., Strathmoor—School District No. 4, c/o H. T. Hart, P. O. Box 84, retained W. H. Adams, Engr., Vinton Bldg., Detroit, and Butterfield & Butterfield, Arch., 1113 David Whitney Bldg., Detroit, to prepare plans for the construction of a 2 story school. A steam heating system will be installed in same. Total estimated cost, $100,000.

Minn., Chisholm—J. P. Vaughan, Supt. of the Board of Education, will receive bids until January 2 for the construction of a 2 story, 68 x 147 ft. grade school. A steam heating and ventilating system will be installed in same. Total estimated cost, $225,000. W. T. Bray, Torrey Bldg., Duluth, Arch. and Engr.

Minn., Duluth—G. Phillips, Comr. of the Duluth Water Light Dept., will receive bids about January 15 for the construction of a 3 story, 50 x 140 ft. office addition on West 1st St. A steam heating system will be installed in same. Total estimated cost, $150,000.

Minn., Minneapolis—The Industrial Investment Co., 807 Hennepin Ave., is having plans prepared for the construction of a 12 story, 200 x 230 ft. theatre and office building on 8th St. and Hennepin Ave. A steam heating system will be installed in same. Total estimated cost, $400,000. J. E. D. Pridmore, 38 South Dearborn St., Chicago, Arch.

N. Y., Charlotte—The Rochester Folding Box Co. plans to construct an addition to its plant on Elizabeth Ave., here. Additional transmission and box making machinery will be installed in same. Total estimated cost, $300,000. E. Z. Adams, Pres.

N. Y., Elba—Wheat's Ice Cream Co., 235 Elm St., Buffalo, has purchased the plant of Flanders Co., here, and plans to alter and install new plant machinery and equipment in same. About $250,000.

N. Y., Long Island City—E. L. Walsh, Superintendent of Public Works, Capitol, Albany, will soon award the contract for installing electric wiring and lighting, power and battery charging equipment for the Barge Canal Terminal at the foot of North Jane St., here.

N. Y., Long Island City—Ballinger & Perrott, Arch., 47 West 34th St., New York City, will soon award the contract for the construction of a 10 story factory on Queens St., for W. P. White, c/o Architects. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

N. Y., New York—The 22 East 70th St. Corporation, 52 William St., will build a 12 story hotel at 22 East 70th St. A steam heating system will be installed in same. Total estimated cost, $400,000. Work will be done by day labor.

N. Y., New York—J. Tishman & Sons, 18 East 41st St., will build a 16 story showroom and office building at 19 West 37th St. A steam heating system will be installed in same. Total estimated cost, $1,200,000. Work will be done by day labor.

N. Y., New York—Charles Steiner, c/o New 14th St. Theatre, 235 East 14th St., plans to build a theatre on 2nd Ave. and 9th St. A steam heating system will be installed in same. Total estimated cost, $300,000. Work will be done by day labor.

N. Y., New York—The Isbrandsen Moller Co., Woolworth Bldg., is in the market for motors, motor trucks and elevators, etc., for altering Piers 12 and 13, which they rented from the city for their own use.

N. Y., New York—The Federal Reserve Bank, 15 Nassau St., is having plans prepared for the construction of a bank building on Maiden Lane, Nassau, Liberty and William St. A steam heating system will be installed in same. Total estimated cost, $2,500,000. York & Sawger, 50 East 41st St., Arch. and Engr.

N. Y., Rochester—The Allen Woolen Mills plans to construct a boiler plant in connection with proposed factory, on Elton and Russel St. Estimated cost, $25,000. Atkinson Allen, Pres.

Ohio, Cincinnati—The Columbia Amusement Co., 7th Ave. and 47th St., New York City, plans to build a theatre on 7th St. near Main St. A steam heating system will be installed in same. Total estimated cost, $400,000.

Ohio, Cleveland—The Ultimate Tire & Rubber Co., Hippodrome Bldg., will soon award the contract for the construction of a 3 story, 80 x 262 ft. rubber tire factory on East 152nd St. Boilers will be installed in same. Total estimated cost, $200,000. R. J. Birch, Pres. and Gen. Mgr. W. S. Ferguson, 1900 Euclid Bldg., Arch. W. F. Ridge, Ohio Bldg., Akron, Engr.

Ohio, Cleveland—E. S. Root, Arch., 1513 University Rd., is receiving bids for the construction of a 2 story, 55 x 58 ft. power house for the Ohio Machine & Boiler Co., 1501 University Rd. A steam heating system will be installed in same. Total estimated cost, $15,000.

Ohio, Cleveland—M. Rabinowitz, 2532 East 22nd St., will soon award the contract for the construction of a 2 story, 40 x 70 ft. warehouse and cold storage plant on 22nd St. Estimated cost, $60,000. Allen Sogg, 319 Hippodrome Bldg., Arch.

Ohio, Cleveland—The Mid West Box Co., 111 West Washington St., Chicago, has plans prepared for the construction of a 3 story, 98 x 402 ft. box factory and power house on West 106th St. and Western Ave., here. A complete power plant will be installed in same. Total estimated cost, $300,000. DeVore Co., 908 Nicholas Bldg., Toledo, Arch. and Engr.

Ohio, Cleveland—The Green Haas Schwartz Co., East 55th St., near Superior Ave., plans to build a 3 story, 164 x 290 ft. factory, boiler house and office building on 105th St. and Elk Ave. Plans include a complete electric plant, consisting of 2 boilers, stokers, condensers, pumps, oil separators and feed water heaters. Total estimated cost, $500,000. Christian, Swarzenberger & Gaeda Co., 1900 Euclid Bldg., Arch.

Ohio, Cleveland—The Gordon Square Co., West 65th St. and Detroit Ave., has purchased a site and plans to construct a 3 story, 150 x 225 x 267 ft. theatre, store, and market house. Two 250 h.p. boilers and valves will be installed in same. Total estimated cost, $700,000. W. G. Caldwell, 1206 Williamson Bldg., Arch.

Ohio, Cleveland—The Citizens Savings & Union Commerce, National Bank Bldg., is having plans prepared for the construction of a 20 story, 258 x 383 ft. bank and office building on Euclid Ave. and 95th St. A complete power plant, consisting of three or four 300 h.p. boilers, stokers, high speed engine, two generators and twelve to twenty 250 h.p. kw. motors will be installed in same. Total estimated cost, $8,000,000. Graham, White, Anderson & Probst, Railway Exchange Bldg., Arch. and Engr.

Ohio, Willoughby—The Zenith Tire & Rubber Co., 456 Leader News Bldg., Cleveland, has had plans prepared for the construction of a 1 and 3 story, 100 x 585 ft. rubber factory and power plant. Total estimated cost, $500,000. A. W. Harris, 829 Schofield Bldg., Cleveland, Arch. and Engr.

Okla., Duncan—Stephens County plans to construct a 4 story, 70 x 80 ft. court house. A steam heating system will be installed in same. Total estimated cost, $150,000. Jewel Hicks, Oklahoma City, Arch.

Okla., Muskogee—The Board of Education will soon award the contract for the construction of two 1 story ward schools. A steam heating system will be installed in same. Total estimated cost, $200,000. C. W. Dawson, 207 Barnes Bldg., Arch.

Okla., Oklahoma City—The Board of Education will soon award the contract for installing heating and ventilating systems in the proposed Webster Junior High School, 11th and Lindsey St.; Classen Junior High School, 17-19 Ellis St., and the Capitol Hill High School, Capitol Hill Addition. J. G. Stearley, 400 North Walnut St., Clk.

Okla., Oklahoma City—The Oklahoma Club will receive bids about January 1 for the construction of a 12 story, 125 x 140 ft. club building. A steam heating system will be installed in same. Total estimated cost, $750,000. Hawk & Parr, 501 Security Bldg., Arch.

Okla., Oklahoma—The Scottish Rites Consistery, Guthrie, plans to construct a 3 story cathedral on the old capitol grounds, here. Plans include refrigerating, heating, ventilating, light and power systems. Total estimated cost, $3,000,000. Hawk & Parr, 501 Security Bldg., Arch.

Okla., Tonkawa—The city sold $15,000 bonds to improve its electric system. Johnson & Benham, Firestone Bldg., Kansas City, Mo., Consult. Engr.

Tex., McKinney—The McKinney Ice & Coal Co. plans to improve its 50 x 50 x 50 ft. ice storage plant, and will be in the market for motor driven refrigerating equipment. Total estimated cost, $300,000. Thomas E. Craig, Mgr.

Tex., Wichita Falls—The Wichita Falls Electric Co. will enlarge its central power station here, and extend its transmission lines to a number of cities and towns. Estimated cost, $1,000,000.

Wis., Milwaukee—The Milwaukee Reliance Boiler Works, 1102 32nd St., plans to construct a 1 story, 70 x 180 ft. boiler plant on 32nd St. Armand D. Koch, Wells Bldg., Arch. and Engr.

Wis., Sheboygan—Cahill & Douglas, Engr., Gross Bldg., Milwaukee, will soon award the contract for the construction of a generating unit, including a 75-100 h.p. D.C. uniflo engine unit, for the Phoenix Chair Co., here.

Wis., South Milwaukee—The Universal Aniline Dyes & Chemical Co., 1009 Wells Bldg., Milwaukee, has purchased site and plans to build a 1, 2 and 3 story manufacturing plant, including a 1 story, 30 x 40 ft. laboratory, power house, warehouse, office building, etc. Total estimated cost, $200,000. O. C. Vehling, 511 First Wisconsin National Bank Bldg., Milwaukee, Arch. and Engr.

Ont., Fort William—The Board of Education plans to construct a 3 story technical school building. A steam heating and fan ventilation system will be installed in same. Total estimated cost, $350,000.

Ont., Toronto—Bowles Lunch, Ltd., 149 Yonge St., are having plans prepared for the construction of a 2 story, 50 x 100 ft. lunch building, on Yonge St. A steam heating system will be installed in same. Total estimated cost, $125,000. Harris & Merritt, 53 Yonge St., Arch.

CONTRACTS AWARDED

Mich., Detroit—Young Brothers, 313 Franklin St., have awarded the contract for the construction of a 1 story, 105 x 200 ft. heating plant, on Franklin Ave., to Ernst Brothers, Bagg St. Noted Sept. 2.

Mich., Hamtramck—The Detroit Carrier & Manufacturing Co., Conant Ave., has awarded the contract for the construction of a 2 story, 110 x 133 ft. factory on Conant Ave. and Grand Trunk R. R., to the Charles M. Davis Co., 1323 Woodward Ave. A steam boiler and engine for heating and power will be installed in same.

Mich., Marysville—Pressed Metals of Canada, 12 Adelaide St., Toronto, has awarded the contract for the construction of a 1 and 2 story, 72 x 516 ft. brass foundry, along the St. Clair River, to The Witherspoon-Englar Co., 53 West Jackson Blvd., Chicago, Ill. A steam heating system will be installed in same. Total estimated cost, $95,000.

Mich., Pontiac—The Board of Education has awarded the contract for the construction of a 2 story school building on West Huron St. to W. H. Isgrigg & Sons, Pontiac. Complete steam heating and ventilating plants will be installed in same. Total estimated cost, $270,000.

Mich., Sault Ste. Marie—The city plans to replace the present steam pumping equipment with 4 electrically driven centrifugal units. Estimated cost, $30,000. W. Rich, Engr.

Mo., St. Louis—The Scullin Steel Co., 6700 Manchester Ave., has awarded the contract for the construction of a 1 story, 20 x 60 ft. transformer building at 1815 Knox Ave., to the Fruin Colnon Contracting Co., Merchants Laclede Bldg. Estimated cost, $12,000.

N. J., Atlantic City—Leeds, Lippincott Co. has awarded the contract for the construction of a 14 story, 132 x 145 ft. addition to the Haddon Hall Hotel on North Carolina St. and Boardwalk, to the Roydhouse Arey Co., 112 North Broad St., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $3,000,000.

Ohio, Columbus—George Bobb & Son, 260 East Naghten St., has awarded the contract for the construtcion of a 5 story, 94 x 178 ft. grocery plant and a 40 x 93 ft. cold storage plant, on Front St., to E. H. Lathan & Co., Columbus Savings & Trust Bldg. Total estimated cost, $190,000. The above contract does not include plumbing, heating, electrical work and special equipment which will amount to $65,000.

Ohio, Cleveland—The Martin Bariss Co., 2048 West 3rd St., has awarded the contract for the construction of a 2 story, 36 x 165 ft. saw mill and power house, to W. B. McAllister Co., 2165 East 31st St. Estimated cost, $100,000. Noted Sept. 2.

Ohio, Cleveland—Marcus Loew, 1493 Broadway, New York City, has awarded the contract for the construction of a 1 story, 96 x 130 ft. theatre on East 101st St. and Euclid Ave., to the Craig Curtiss Co., Guardian Bldg. A steam heating system will be installed in same. Total estimtaed cost, $250,000.

Okla., Ada—The city has awarded the contract for constructing and furnishing service and fire pumps, all piping, etc., in connection with the proposed waterworks extensions, to the Merkle Machinery Co., 508 Interstate Bldg., Kansas City, Mo. Total estimated cost, $20,500.

LEGAL NOTICE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of Power, published weekly at New York, N. Y., for Oct. 1, 1919.

State of New York } ss.
County of New York }

Before me, a notary public in and for the State and county aforesaid, personally appeared James H. McGraw, Jr., who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Co., Inc., publishers of Power, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, McGraw-Hill Co., Inc., 10th Ave. at 36th St., New York, N. Y. Editor, Fred Low, 10th Ave. at 36th St., New York, N. Y. Managing Editor, A. D. Blake, 10th Ave. at 36th St., New York. Business Manager, G. E. Andrews, 10th Ave. at 36th St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent. or more of the total amount of stock.) McGraw-Hill Co., Inc., 10th Ave. at 36th St., New York, N. Y. James H. McGraw, 10th Ave. at 36th St., New York, N. Y. Arthur J. Baldwin, 10th Ave. at 36th St., New York, N. Y. John McGhie, 10th Ave. at 36th St., New York, N. Y. Fred Low, 10th Ave. at 36th St., New York, N. Y. Henry W. Blake, 10th Ave. at 36th St., New York, N. Y. Leonard D. Baldwin, 27 Pine St., New York, N. Y. F. S. Weatherby, 163 Clinton Road, Brookline, Mass. Arthur J. Baldwin, 10th Ave. at 36th St., New York, N. Y. Trustee for Estate of John A. Hill, Morgan Baldwin, Donald Baldwin, Franklin Baldwin, Grace Baldwin and Cynthia Haselton.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is . (This information is required from daily publications only.)

JAMES H. McGRAW, JR.

Sworn to and subscribed before me this 27th day of September, 1919.

[Seal.] MARTIN J. WIEMER.

Notary Public, Kings County Certificate No. 103. Certificate filed in New York County No. 316.

My commission expires March 30, 1920.

PRICES--MATERIALS--SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		75c. per ft.
Common, 2½-in.		40%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.50	$0.33	$0.22

Steam—Discounts from List

First grade.....30% Second grade.....40% Third grade.....45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition.....65% Best grade.....35%
Standard.....50%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	40%	30%
Chicago	20%	10%
Birmingham	35%	30%
Denver	30%	20%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.50
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.10
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ¼- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin. Ft.	Thickness	Price Per Sq. Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

For low-pressure heating and return lines: 4-ply.....58% off; 3-ply.....60% off; 2-ply.....62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	6.6	6.7	8½	13
Fiber or sponge	8	10	8.6	13	9	18
Transmission	7	9	8.1	13	8½	15
Axle	4½	6	4.8	4.75	4½	5½
Gear	4½	9	6.1	7.5	8½	8
Car journal	22(gal.)	21(gal.)	4.7	4.7	4½	15¾

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago	Current	Current
White	13.00	11.00 to 13.00	14.00	12.00 to 15.00
Colored mixed	9.00 to 12.00	8.50 to 11.00	11.00	9.50 to 13.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	43.00	45.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland	Chicago	
	Current	One Year Ago	Current	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.75	$1.61	$2.50	$1.98	$1.65
5-gal. cans	1.90	1.76	2.75	2.23	1.85

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	14.00	14.50	13.00	14.00
25- and 50-lb. kegs	13.25	14.75	14.25	12.75	13.25	14.25
12½-lb. keg	13.50	15.00	14.50	15.00	13.50	14.50
1-lb. cans	16.00	17.50	.....	.....	16.00	17.00
5-lb. cans	15.00	16.50	.....	.....	15.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10-2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50-10%	55%	55%
Tinned	50-10%	55%	50%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:
New York....$5.25 Cleveland....$4.00 Chicago.....$4.72 Pittsburgh....$4.65

Structural rivets, same sizes:
New York....$5.35 Cleveland....$4.10 Chicago.....$4.92 Pittsburgh....$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$80-90	at Chester, Penn.
Chrome cement	net ton	45-50	at Chester, Penn.
Clay brick, 1st quality fireclay	net M	35-45	at Clearfield, Penn.
Clay brick, 2nd quality	net M	30-35	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50	at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90	at Chester, Penn.
Silica brick	net M	41-45	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.

Birmingham—Silica, $50 per M; fire clay, $43 per M; magnesite, $80 per ton; chrome, $80 per ton.

Chicago—Second quality, $25 per ton

Denver—Fire clay, $11 per ton.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	95.00	70.00	93.00	60.00	96.00
Commercial	55.00	50.00	16.50	23.00	13.00	25.00

SWEEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$21-26	$19.00
Cleveland	20.00	20.00
Chicago	16.50	19.00

In coils an advance of 50c. is usually charged.

COAL—Bituminous:

Prices in effect throughout the United States on Dec. 31, 1918, have been restored by Government order:

NEW YORK Per net ton, F. O. B. Tidewater		PITTSBURGH Per net ton, F. O. B. Cars at Mine	
Central Penna., Mine Run or Slack	$5.45		
Upper Potomac, Cumberland and Piedmont Fields			
Mine Run	5.23		
Prepared	5.51	Slack	$2.10 @ $2.25
Slack	4.95	Mine Run	2.35 @ 2.50
Upper ports, 5c. higher		Screened	2.60 @ 2.75

PHILADELPHIA F. O. B. Cars		
	Mine	Tidewater
Nut	$5.15	$6.50
Stove	5.05	6.40
Egg	4.80	6.15
Broken	4.90	6.25
Pea	3.75	5.00
Buckwheat	3.40	4.45
Rice	2.90	3.80
Boiler	2.70	3.70
Barley	2.40	3.15

MIDDLE WEST
Chicago quotations, F. O. B. cars at mine

	Springfield Carterville Williamson Franklin Saline Harrisburg	Fulton Peoria	Grundy La Salle Bureau Will
Lump	$2.55 @ $2.70	$2.95 @ $3.10	$3.25 @ $3.40
Washed	2.75 @ 2.90	.....	3.45 @ 3.60
Mine Run	2.35 @ 2.50	2.75 @ 2.90	3.00 @ 3.15
Screenings	2.05 @ 2.20	2.35 @ 2.50	2.75 @ 2.90

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron	
Inches	Black	Galvanized	Inches	Black / Galvanized
⅛, ¼, and ⅜	50½%	24%	¼ to 1¼	39½% / 23½%
½	54½%	40%		
¾ to 3	57½%	44%		

LAP WELD

2	50½%	38%	2	32½% / 18½%
2½ to 6	53½%	41%	2½ to 6	34½% / 21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	¼ to 1¼	39½% / 24½%
½	51½%	39%		
¾ to 1¼	55½%	43%		

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½% / 20½%
2½ to 4	51%	40½%	2½ to 4	35½% / 23½%
4½ to 6	50%	39½%	4½ to 6	34½% / 22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
⅛ to 3 in. steel butt welded	47%	31%	43½%	34½%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	45½%	30½%	53½%	41%

Malleable fittings. Class B and C, from New York stock sell at list +12½%
Cast iron, standard sizes, 10-5% off.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3¼ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3½ in.	30½	3 to 3½ in.	1
2½ in.	24	2½ to 2⅝ in.	+1
1¼ to 2 in.	19½	2 to 2½ in.	16
		1¾ to 1⅞ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

Per Net Ton		Per Net Ton	
1 in.	$327	1¾ in.	$207
1½ in.	267	2 to 2½ in.	177
1¾ in.	257	2¾ to 3¾ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiations.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B.& S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size, red seal, Columbia or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.39
50 to 125 (bbl.)	.36
125 (bbl.) or over	.34

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and over	Galvanized 1,000 Ft. and over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 1,000 and Over
¼	$71.15	$76.25	$17.04	$18.18	$5.38	$5.74
⅜	71.15	76.25	17.04	18.18	6.25	6.70
½	93.96	100.86	22.23	23.93	8.97	9.57
1	138.39	149.09	33.19	35.41	11.66	12.44
1¼	187.91	201.71	42.62	45.31	16.10	17.12
1½	224.68	241.18	56.82	60.62	19.89	21.15
2	302.29	324.49	104.17	110.77	26.52	28.20
2½	477.95	513.05	170.46	181.26	37.88	40.28
3	625.00	670.91	454.56	483.36	56.82	60.42
3½	779.24	834.44	1,003.82	1,067.42	75.76	80.56
4	945.03	1,010.43	1,160.08	1,223.57	94.70	100.70

5% cash 10 days.
From New York Warehouse—5% cash.
Standard lengths rigid, 10 ft. Standard lengths flexible, 100 ft. Standard lenghts flexible, ¼ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
7/32	250	$0.05½	
⅜	250	.06	
½	250	.09	
¾	200	.12	
1	200	.15	Coils.....55% off
1¼	150	.18	Less coils,..45% off
1½	100	.25	
1¾	100	.33	
1¾	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are the net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. P.	$0.24
D. P. M. L.	.11	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$16.75
No. 16 cotton twisted	22.00
No. 18 cotton parallel	19.80
No. 16 cotton parallel	25.75
No. 18 cotton reinforced heavy	30.00
No. 16 cotton reinforced heavy	36.50
No. 18 cotton reinforced light	23.40
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	26.00
No. 16 cotton Canvasite cord	28.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp to 100-amp.	50	.90
110-amp to 200-amp.	25	2.00
225-amp to 400-amp.	25	3.60
425-amp to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount:	
Less than 1-5th standard package	30%
1-5th to standard package	40%
Standard package	52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75 C
0-30 ampere, less than standard package	6.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B—				Pear-Shape Bulbs Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.35	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Soild Single Braid	Solid Double Braid	Stranded Double Braid	Duplex'
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	—15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.& S. regular spools (approx. 8 lb.)	36c. lb.
No. 18 B.& S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb., 50c. lb., 100 lb. lots	55c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb., 50c. lb., 100 lb. lots	46c. lb.
Soldering paste. 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole Each	Fore Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—14%
$50 to $200 list value	—20%
$200 list value or over	—25%